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DESIGN DEFINITION STUDY OF A LIFT/CRUISE FAN TECHNOLOGY V/STOL AIRCRAFT

VOLUME I

NAVY OPERATIONAL AIRCRAFT

BY

V/STOL AIRCRAFT ADVANCED ENGINEERING

PREPARED UNDER CONTRACT NO. NAS 2-5499 BY

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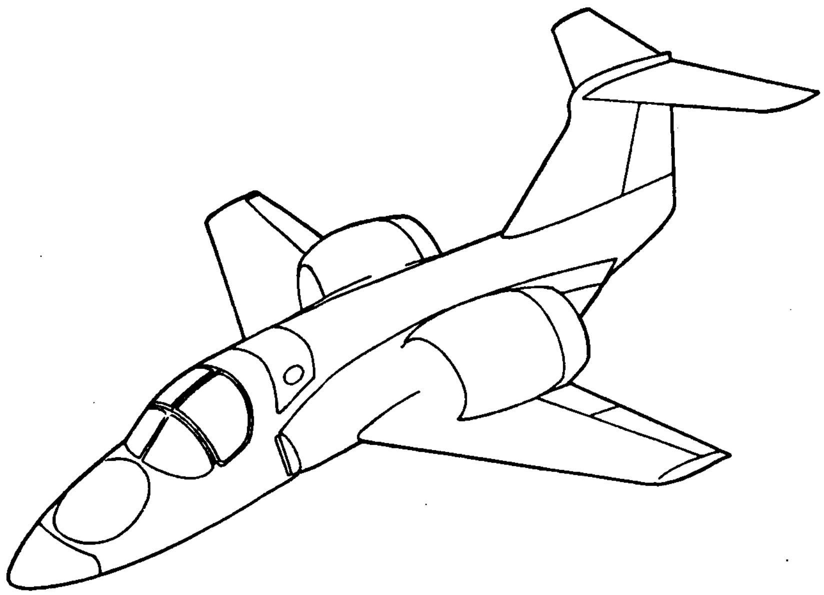
FOR
AMES RESEARCH CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY

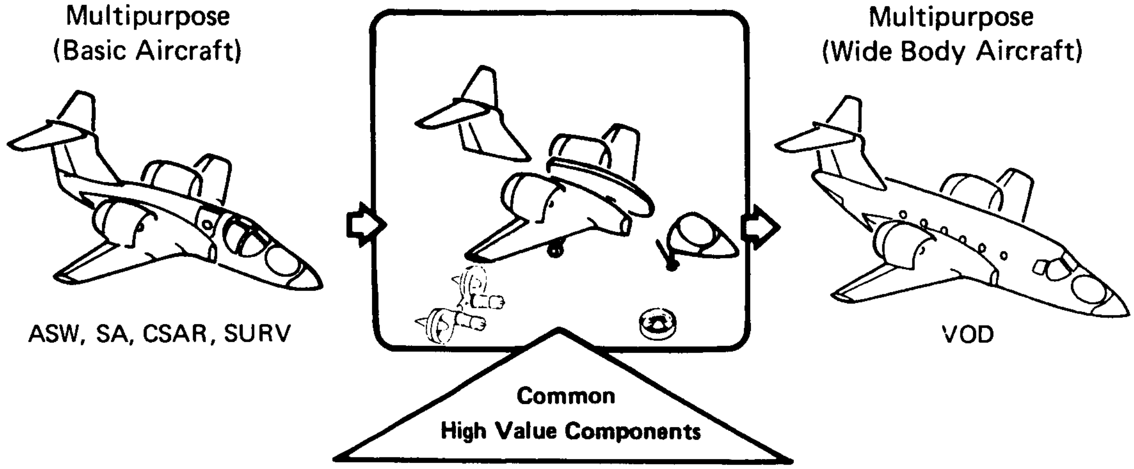
This report presents results of Part I of a study by McDonnell Aircraft Company for NASA Ames Research Center and the U.S. Navy to define a Lift/Cruise Fan V/STOL Aircraft. The purpose of Part I of the study was to define a multi-purpose lift/cruise fan V/STOL aircraft which could meet the various Navy mission requirements and be available for operational deployment in the mid 1980's.

Five missions were established for evaluation: Anti-Submarine Warfare (ASW), Surface Attack (SA), Combat Search and Rescue (CSAR), Surveillance (SURV), and Vertical On-Board Delivery (VOD). All missions were performed with a short takeoff and a vertical landing. The aircraft were to be defined using existing J97-GE gas generators or reasonable growth derivatives in conjunction with turbo-tip fans reflecting LF460 type technology. The multipurpose aircraft configuration established for U.S. Navy missions is illustrated below and is a culmination of many years of effort by MCAIR in developing the turbotip driven lift/cruise fan concept for V/STOL aircraft. This in-depth background was used throughout the study to assure the validity of the results and to arrive at the most efficient integration of airframe and components.



Missionized aircraft were designed and sized to meet all the requirements for each of the specified missions. The gas generator sizes varied from the existing J97 at 70 lb/sec airflow to a maximum of 86 lb/sec airflow and the fan diameters varied from 57 to 61 inches. All configurations used three fans: two over-the-wing lift/cruise fans and one nose mounted lift fan. The ASW, SA and CSAR aircraft used two gas generators but the SURV and VOD required three gas generators to provide engine out vertical landing capability. The vertical landing requirement with a gas generator out was a major design criterion affecting configuration development. The third gas generator was required in the SURV due to the high fixed weight of non-expendable avionic equipment and in the VOD due to the 5000 lb of passengers. Takeoff gross weights (STOGW) of the aircraft varied from 33,300 lb (CSAR) to 44,800 lb (VOD) and lengths varied from 47.9 feet (SA) to 56 feet (VOD).

These five missionized aircraft were then evaluated to establish a compromise mission and a commonality approach for the multipurpose aircraft. It was found impractical to apply the VOD cargo fuselage volume to the other missions due to the excessive performance penalties involved. Therefore, the commonality approach selected, as illustrated below, was to design one multipurpose aircraft for the ASW, SA, CSAR and SURV missions and to use a wide body version with common high value components for the VOD mission.

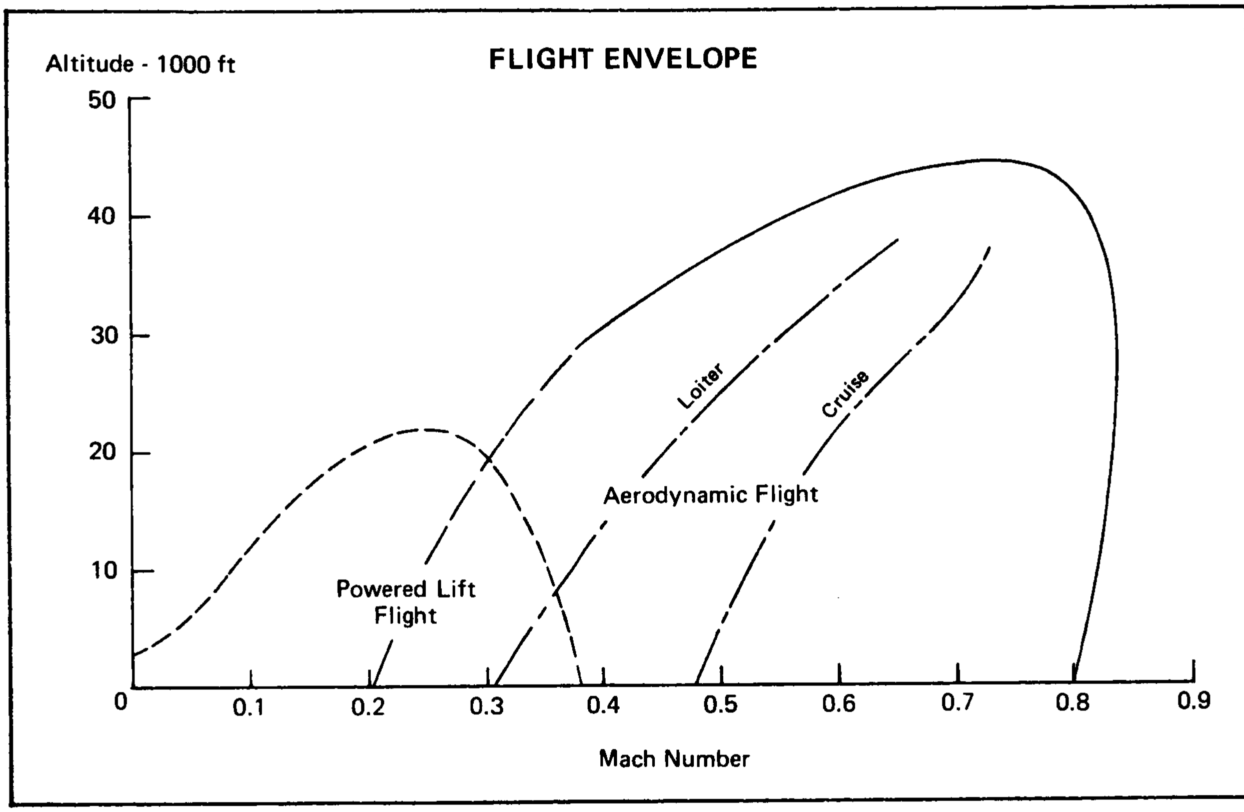


The basic multipurpose aircraft configured was 48.4 ft in length and used two growth (80 lb/sec) J97 gas generators with three 59 inch diameter turbotip driven fans. When operated at the prescribed takeoff conditions of 400 ft deck roll and 10 kt WOD, the aircraft had a STOGW of 38,700 lb and essentially met all of the requirements for the ASW, SA, CSAR and SURV missions. The minor compromises to the individual missions accepted for the multipurpose configuration were common design q, common design velocity, and rolling vertical landing (RVL) with one engine out for the SURV mission.

The multipurpose wide body VOD was 56.7 ft in length and used common wing, empennage, fans, nose and landing gear. At the prescribed takeoff conditions of 450 ft deck roll and 20 kt WOD, the VOD had a STOGW of 45,000 lb and could meet all mission requirements. Three existing (70 lb/sec) J97 gas generators were used to provide engine out vertical landing capability with passengers on-board. Two additional VOD alternate configurations were offered in addition to the study requirements; i.e., two growth (80 lb/sec) J97 gas generators, as in the basic aircraft, and accept an RVL of less than 100 ft with an engine out; and, three growth gas generators providing vertical landing capability in conjunction with additional mission capabilities.

Additional studies were conducted on the multipurpose aircraft to identify acceptable operational procedures which would result in significant performance improvements. Included in these considerations were the use of a 2 ft sink off-the-bow, such as that used for Harrier performance, vice the zero sink allowed by study ground rules; and, the use of single engine loiter since an alternate engine start capability is available from the jet fuel starter.

The lift/cruise fan V/STOL aircraft configured by this study exhibits high speed (M = 0.83) and high altitude (>40,000 ft) as illustrated in the following flight envelope. This capability coupled with long endurance at extended mission radii provides a new dimension for V/STOL aircraft. The results of this study indicate that a multipurpose V/STOL aircraft, operationally suitable for air capable ships, can be designed to meet the Navy needs in the mid 1980's without high risk development.



At the end of this study, new propulsion performance predictions were received from General Electric Co. based on their current contracted NASA/NAVY study. The thrust and SFC's were improved; however, the fan and engine weights were also increased. These changes were evaluated for the ASW mission and the mission performance was unchanged. Therefore, the Multipurpose aircraft performance shown is considered valid for the latest propulsion system estimates.

INTRODUCTION

Recent studies by the Navy and NASA have confirmed the future need for a high performance V/STOL aircraft for both military and civil applications. The Navy requires a multimission V/STOL aircraft in the 1980's capable of sea control operations from many platforms as well as ship-to-shore and shore-to-ship functions. The objectives of this study may be summarized as follows:

Part I: Define a multimission V/STOL aircraft for use by the U.S. Navy in the 1980's.

Part II: Define alternate approaches for developing a flight vehicle to demonstrate the proposed lift cruise fan concept.

The results of this study are reported in the following three volumes:

Volume I - Navy Operational Aircraft

Volume II - Technology Flight Vehicle Definition

Volume III - Technical Data Addendum.

The turbotip lift/cruise fan V/STOL aircraft exhibits an excellent potential for multimission V/STOL applications because of its high speed, high altitude and extended range capability coupled with its overall operational suitability. MCAIR has been actively pursuing the lift/cruise fan concept since 1960 and has accumulated a significant technical data base. One of the important developments was the MCAIR patented Energy Transfer and Control (ETaC) system which transfers gas energy as required to attain attitude control about the pitch and roll axes with an insignificant change in total lift. ETaC takes advantage of the inherent gas generator transient characteristics which allow the gas generators to be sized for cruise conditions. This is in direct contrast to other control systems (spoilage or bleed) which require the gas generator to be approximately 20% oversized to provide control capability, resulting in higher weights and SFC.

The data base which includes component development, system integration, high and low speed wind tunnel tests, and flow field evaluation was applied during this study to establish the configurations for both missionized and the multipurpose aircraft. The key features incorporated in all designs are: tripod lift arrangement using three identical single stage fans; fan-over-wing placement for maximum induced lift; proper fan arrangement and spacing to eliminate negative ground effects; proper center of thrust and center of gravity locations to assure efficient trim and simple thrust vectoring schedules; T-tail for a favorable powered lift downwash field and characteristics; and, incorporation of the ETaC system.

The specified Mission Requirements and Design Guidelines are presented in Appendix A of this report. In addition, the following design guidelines were established to assure a cost effective, operational aircraft design:

- Use existing J97-GE gas generators or reasonable derivatives to minimize cost
- Use state-of-the-art technology in fan design to assure an aircraft IOC in the mid 1980's

o Use two engine operation for aircraft cruise and loiter

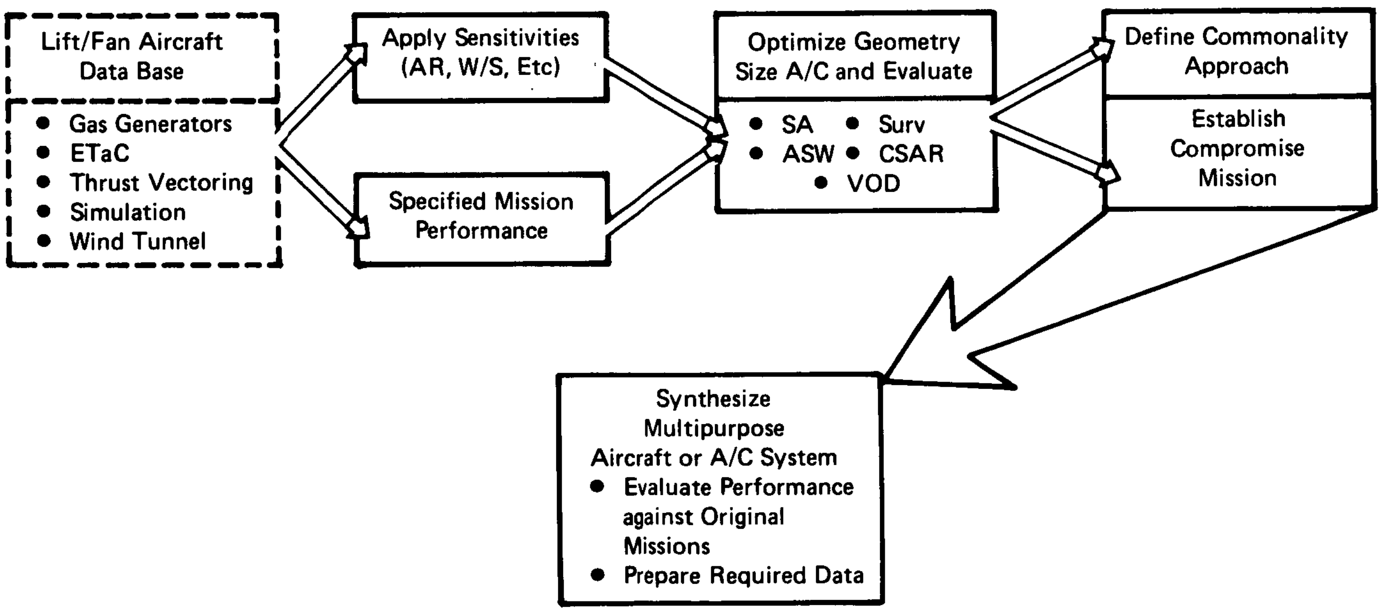
o Use zero sink off-the-bow for STO performance.

Application of these criteria to the initial aircraft design, although somewhat conservative, provides a high confidence level in the aircraft's capability to meet the mission requirements and achieve an IOC in the mid 1980's.

The tasks performed in this Part I study are shown in the following Work Flow Diagram.

NASA/NAVY TECHNOLOGY AIRCRAFT STUDY

Task Summary - Part I



Individual aircraft were designed to meet all the requirements for their particular mission and are referred to as missionized aircraft. These aircraft designs are discussed in Section 1. The missionized aircraft were then evaluated to define a Compromise Mission and Commonality Approach which is presented in Section 2. Based on this commonality approach, a multipurpose aircraft was synthesized and evaluated against the established missions. The multipurpose aircraft essentially met all of the mission requirements and is presented in Section 3.

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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

SYMBOLS AND ABBREVIATIONS

ACS	Active Control System
AMAD	Airframe Mounted Accessory Drive
ASW	Anti-Submarine Warfare
AR	aspect ratio
b	wing span, ft (meters)
BCAV	Best Cruise Altitude and Velocity
C_{D_o}	zero lift drag coefficient
C_L	lift coefficient
CNI	Communication, Navigation, Identification
CSAR	Combat (Strike) Search and Rescue
D_{FT}	fan tip diameter, ft (meters)
EGT	Exhaust Gas Temperature, degrees
ESM	Electronic Support Measures
ETaC	Energy Transfer and Control
f	drag area, ft^2 ($meters^2$)
FCS	Flight Control System
FLIR	Forward Looking Infra-Red
g	gravitational constant, 32.2 ft/sec
GG	gas generator
GW	gross weight, lb (Newtons)
HUD	Headup Display
IOC	Initial Operational Capability
K	induced drag factor
KEAS	equivalent airspeed, kt
kt	knots
KTAS	true airspeed, kt

M	Mach Number
MAD	Magnetic Anomaly Detection
NM, nm	nautical miles
OWE	Operating Weight Empty, lb (Newtons)
q	dynamic pressure, psf (Newtons/meter^2)
RVL	Rolling Vertical Landing
S	area, ft^2 (meters^2)
S_W	wing area, ft^2 (meters^2)
SA	Surface Attack
SENSO	Sensor Operator
SFC	Specific Fuel Consumption, lb/hr/lb
SL	sea level
STO	Short Takeoff
STOL	Short Takeoff and Landing
STOGW	Short Takeoff Gross Weight, lb (Newtons)
SURV	Surveillance
TACCO	Tactical Coordinator
TO	takeoff
t/c	airfoil thickness ratio
TDPR	Turbine Discharge Pressure Ratio
TIT	Turbine Inlet Temperature, degrees
TOGW	Takeoff Gross Weight, lb (Newtons)
TOS	Time on Station, hr
TRM	Thrust Reduction Modulation
V_c	climb speed
VL	Vertical Landing
VOD	Vertical Onboard Delivery

VTO	Vertical Takeoff
VTOGW	Vertical Takeoff Gross Weight, lb (Newtons)
VTOL	Vertical Takeoff and Landing
V/STOL	Vertical/Short Takeoff and Landing
W_A	airflow rate, lb/sec (kilograms/sec)
WOD	Wind Over Deck, kt
W/S	wing loading, psf (Newtons/meter^2)
ζ	damping coefficient
$\Lambda_{c/4}$	sweep angle of quarter chord, deg
λ	wing taper ratio
w_n	undamped natural frequency, rad/sec

1. MISSIONIZED AIRCRAFT

1.1 SUMMARY

Individual aircraft were designed for the five specified missions: Anti-Submarine Warfare (ASW), Surface Attack (SA), Surveillance (SURV), Combat Search and Rescue (CSAR), and Vertical On-board Delivery (VOD). Each was configured to fulfill all the requirements of the study guidelines, Appendix A, without compromise. The propulsion system, wing area, and aspect ratio were varied until the aircraft met the mission requirements at a minimum STOGW.

The existing J97 gas generator was determined, through consulation with General Electric Co., to have a maximum reasonable growth capability from 70 lb/sec to approximately 86 lb/sec airflow. The gas generator operational mode was to use dry ratings for takeoff and water uprating for emergency engine out vertical landings. The engine-out, vertical landing requirement of landing at OWE plus 1000 lb of fuel without exceeding 15 fps rate of sink required the two gas generator system for the SURV and VOD to exceed the 86 lb/sec limitation. The flexibility of the gas coupled system permitted the addition of a third gas generator. Therefore, the SURV and VOD aircraft were configured with three existing J97 engines to satisfy the engine out vertical landing.

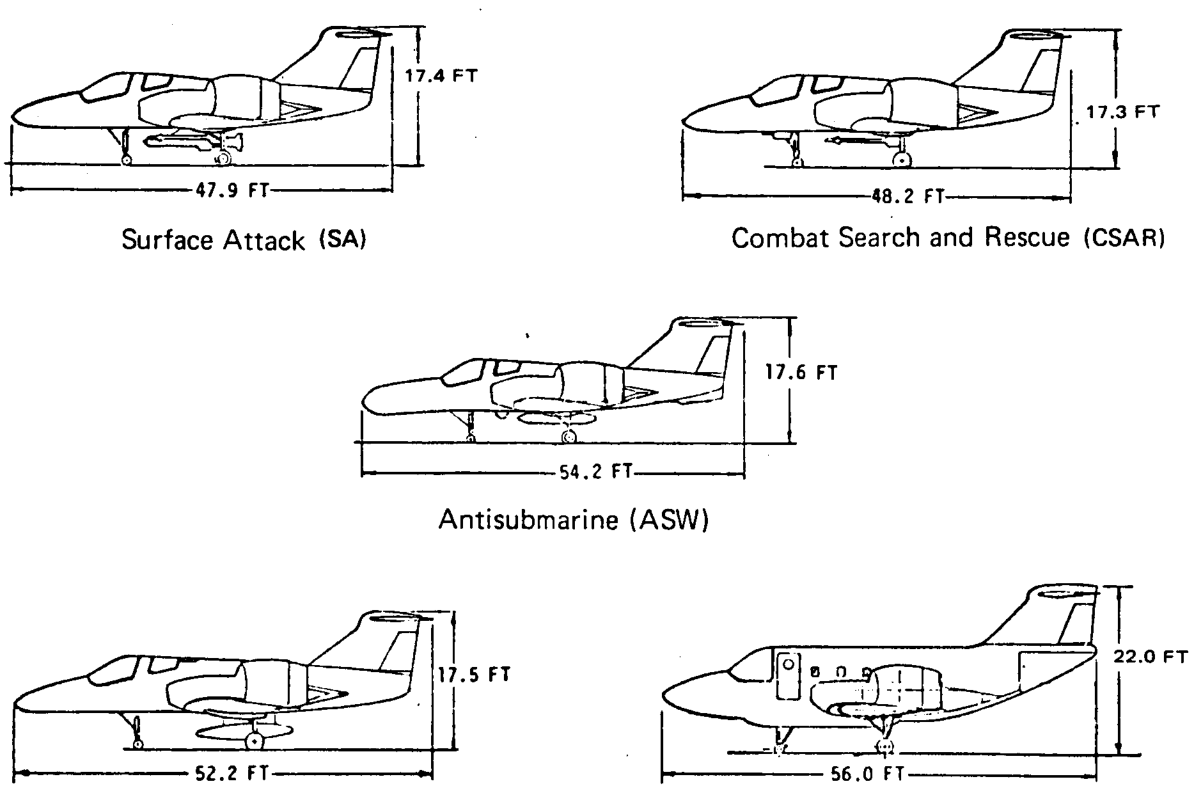
An analysis was conducted of the short landing characteristics with an engine out. It was determined that the two engine versions of the SURV and VOD, with one of these engines inoperative, could land in less than 100 ft with 20 kt WOD. This would be a viable alternative to the engine out requirement since it would result in smaller aircraft and decreased maintenance and logistics support.

All configurations were designed to incorporate the following features: three fans (1 lift and 2 lift/cruise), ETaC interconnect system, low wing, T-tail, and J97 type gas generators. In addition to being sized for the required mission loads, each design incorporated the following design features except as noted:

- Wing fold
- Extendable nose gear
- Automatic landing and all weather capability
- CNI and navigation (with some variations)
- Five external store stations (3 wet). VOD has three wet only.
- Emergency jettison of all stores with gear down
- Pressure fueling and dumping capability
- Inflight refueling
- Zero/zero seats (ditching provisions only for VOD)
- Self-contained starting system

Wing fold and extendable gear features permit operations on a deck edge elevator (34 ft by 50 ft) within the height clearance of 19 ft. The extendable gear provides improved STO performance as well as aiding in hangar deck stowage or maintenance. The configurations of the five missionized aircraft are summarized in Figure 1-1 and the major characteristics are summarized in Figure 1-2.

FIGURE 1-1
MISSIONIZED AIRCRAFT



Surface Attack (SA)

Combat Search and Rescue (CSAR)

Antisubmarine (ASW)

Surveillance (SURV)

Vertical Onboard Delivery (VOD)

FIGURE 1-2
MISSIONIZED AIRCRAFT CHARACTERISTICS SUMMARY

	ASW	SA	SURV	CSAR	VOD
STOGW (lb) (N)	42,900 (190,820)	34,600 (153,900)	38,800 (172,580)	33,300 (148,120)	44,800 (199,270)
OWE (lb) (N)	22,841 (101,596)	19,546 (86,940)	24,777 (110,208)	21,248 (94,511)	21,756 (96,770)
Landing Wt. (Engine Out) (lb) (N)	23,841 (106,045)	20,546 (91,388)	25,777 (114,656)	22,648* (100,738)	27,756 (123,458)
Wing Loading at STOGW (lb/ft^2) (N/m^2)	86 (4,120)	99 (4,742)	97 (4,646)	104 (4,981)	112 (5,364)
Wing Area (ft^2) (m^2)	500 (46.45)	350 (32.52)	400 (37.16)	320 (29.73)	400 (37.16)
Aspect Ratio	5.0	4.5	4.5	4.0	5.7
Gas Generators	2	2	3	2	3
Airflow (lb/sec) (Kg/sec)	86 (39.01)	75 (34.02)	70** (31.75)	80 (36.29)	70** (31.75)
Fan Dia. (in.) (m)	61 (1.55)	57 (1.45)	59 (1.50)	59 (1.50)	59 (1.50)
Design Fan Pressure Ratio	1.32	1.32	1.32	1.32	1.32
Mission Load (lb) (N)	6,732 (29,944)	4,902 (21,804)	7,037 (31,300)	2,771 (12,325)	6,250 (27,800)
Mission Fuel (lb) (N)	16,720 (74,370)	11,993 (53,345)	14,023 (62,374)	11,662 (51,872)	18,044 (80,260)
M_{Cruise} (Opt. Altitude)	0.74	0.74	0.74	0.74	0.73

*Includes passengers/evacuees plus 1000 lb fuel.
**Existing J97 performance.

1.2 MISSIONIZED PERFORMANCE

The missionized aircraft that comply with the specified design requirements were defined initially by application of the MDC V/STOL aircraft technology data base. This data base includes recent results from numerous lift cruise fan aircraft and power plant study programs, both theoretical and experimental, that are directly applicable to the current study. Wing loading and aspect ratio, VTO gross weight, and the J97-GE gas generator derivatives were established and used for design layout, weights, drag estimation, and mission performance evaluation. The initial designs were refined or iterated as required to meet the mission requirements. All mission performance was machine computed (KC-14 program) using simplified polars. The resulting wing geometry and drag polars are shown in Figure 1-3.

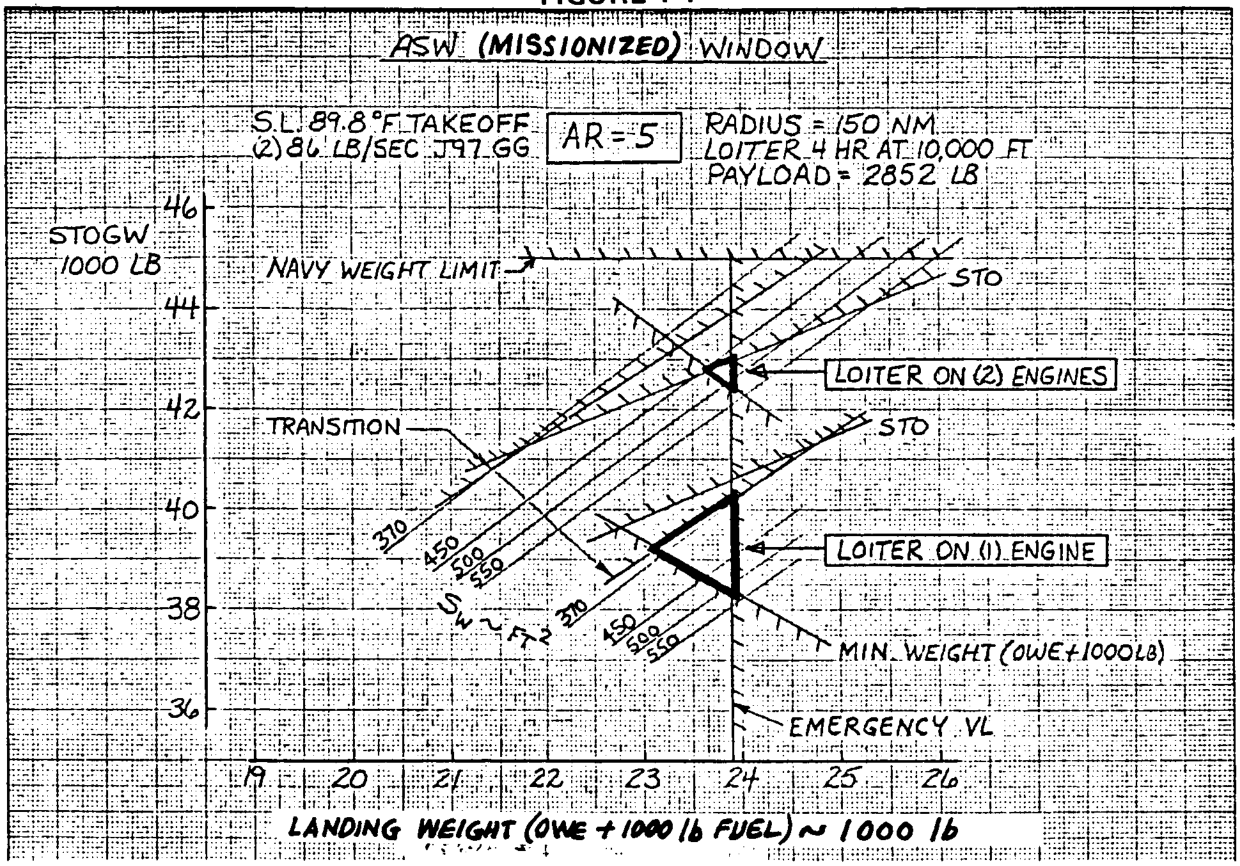
FIGURE 1-3
MISSIONIZED AIRCRAFT POLARS

Aircraft	Wing Geometry Area	Wing Geometry Aspect Ratio	Polar $[C_{D_0} + K\, C_L^2]$
ASW	500	5.0	$0.0256 + 0.0848\ C_L^2$
SA	340	4.5	$0.0285 + 0.0942\ C_L^2$
SURV	400	4.5	$0.0266 + 0.0942\ C_L^2$
CSAR	320	4.0	$0.0301 + 0.106\ C_L^2$
VOD	400	5.7	$0.0317 + 0.0745\ C_L^2$

Anti Submarine Warfare Aircraft

The iterative design approach for the missionized ASW aircraft was validated by construction of point design windows to assure the proper selection of wing area and aspect ratio. Design windows were constructed for wing aspect ratios of 4.5, 5.0, and 5.5 using two gas generator operation on all mission segments. The design window for the selected aspect ratio of 5.0 is presented in Figure 1-4. Referring to Figure 1-4, the constant wing area lines labeled S_W, running from lower left to upper right, define the possible mission TOGW and landing weight (O.W.E. + 1000 lb fuel) combinations that satisfy the specific mission requirements for the selected gas generator size. Next, the practical limits of current technology, that is, the design window was established. The gas generator size defines the aircraft VTO gross weight. This VTOGW in conjunction with an assumed wing area establishes a reference VTO wing loading and a corresponding STO gross weight for the prescribed take-off conditions, 400 ft and 10 Kt WOD. The 400 ft 10 Kt WOD limit line, running from lower left to upper right, shown on the chart results from analyzing various wing areas. Gas generator size also established the emergency engine-out vertical landing capability, vertical line, defined by the sum of installed vertical lift (emergency, wet rating) plus the vertical drag of the aircraft in a 15 ft/sec rate of sink condition. Aircraft weight analyses provided the minimum, state of the

FIGURE 1-4



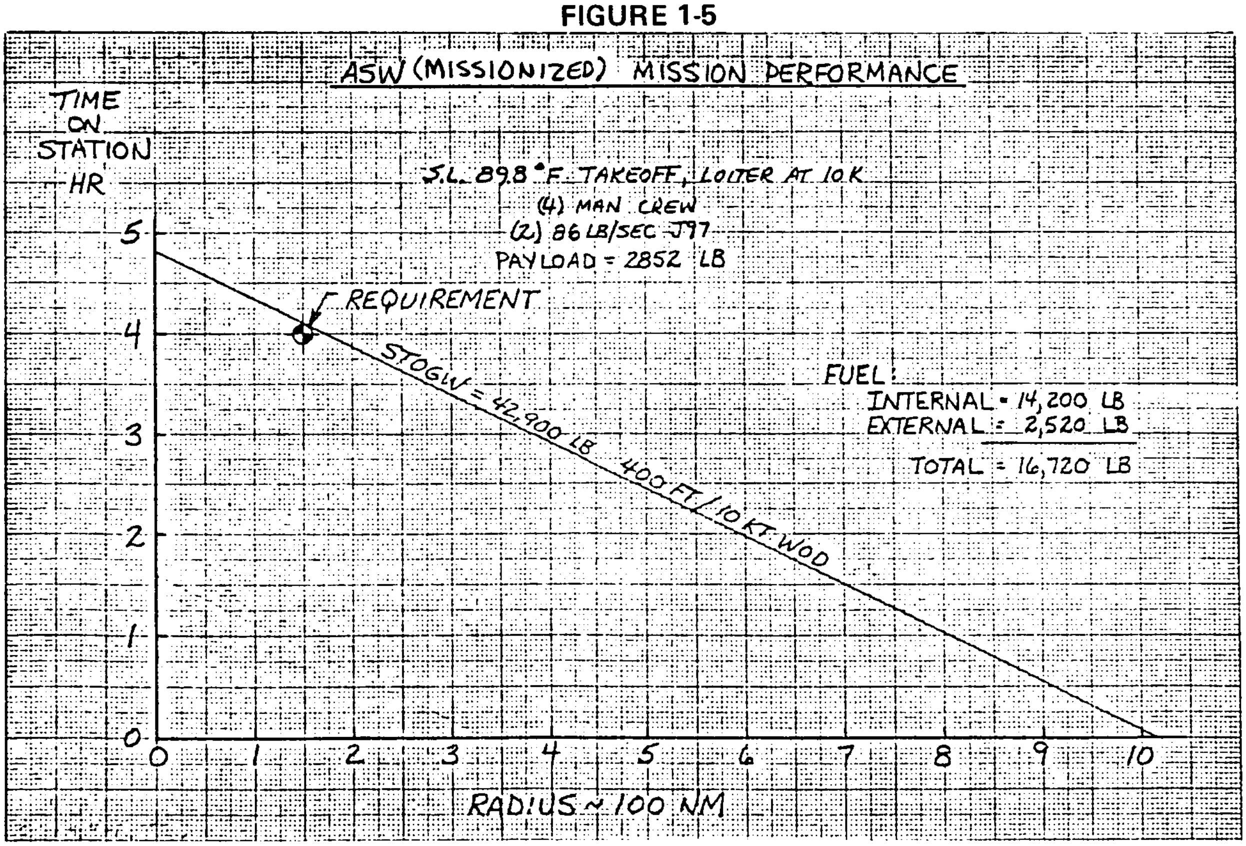
art, operating weight empty for the assumed aircraft geometry and specified mission equipment loading. This OWE plus 1000 lb of fuel establishes the minimum weight line (running from upper left to lower right) shown. The three boundary lines generally define the aircraft design window, the area outlined by heavy lines on the reference plots. Two other criteria are shown, the Navy specified gross weight limit of 45,000 lb and the transition capability defined by the conversion velocity overlap of 20% of the wingborne flight stall speed for hot day operating conditions. Secondary criteria not shown on the window plots but which are considered when selecting the aircraft geometry include items such as cost, spotting factor, and ride quality. These items are benefited by small size and high wing loading that translate into lower landing weight together with lower wing area and aspect ratio.

The design window size decreases and shifts to smaller wing areas as wing aspect ratio increases. The window vanishes at approximately an aspect ratio of 6.0, and the complete ASW mission requirements cannot be fulfilled with larger aspect ratios using the assumed state-of-the-art technology level. The point design window would be enlarged and the permissible aspect ratio would increase if the technology level was increased to reflect greater thrust/weight ratios and propulsive efficiencies for lift cruise fan systems, improved STO/VTO gross weight ratio and lift/drag ratio, or reduced mission avionics/equipment weight. The technology levels used in this report reflect the results of the MCAIR lift cruise fan study program and a continuing dialogue with NASA, Navy and General Electric Co.

The point design window is also influenced by operational variables. Figure 1-4 also presents a comparison of the ASW point design windows for an aspect ratio of 5.0 assuming either two or one gas generator operation as the design method of operation during the 4-hour loiter period. The significant changes for one gas generator operation other than the window size are the potential 4000 lb (9.1%) STOGW reduction, the 1000 lb (4.2%) landing weight reduction, and the 130 sq ft (26%) wing area reduction. The decrease in wing area increases the wing loading to the extent that the transition criterion supplants the STO criterion. The smaller wing area together with the reduced aircraft size benefits the spotting factor and reduces the wing fold weight penalty.

Figure 1-5 presents the selected ASW missionized aircraft (STOGW = 42,900 lb) mission performance of loiter time on station as a function of the radius of operation. At the specified radius of 150 nm, a 4.1 hour loiter period at 10,000 ft altitude is indicated using a total fuel of 16,720 lb. The takeoff fuel allowance includes 1/2 minute operation for the short term takeoff rating; all estimated fuel consumptions are for standard day operation and are increased 5% for service tolerance. Cruise is performed at best altitude and velocity (BCAV) with a maximum altitude limitation of 36,089 ft for mission performance evaluation. Higher altitudes are possible, but the benefit in mission performance is slight; estimated effects for high altitude operation are shown and discussed in the VOD section. The takeoff conditions are a 400 ft deck run with 10 knots WOD and zero sink off the bow with a minimum acceleration of 0.065 g on a sea level, 89.9°F day (Tropical day). The STO gross weight is determined from STO performance charts of STOGW/VTOGW ratio as a function of deck roll distance and WOD (see Section 3 discussion). The VTOGW is defined by the power plant selection and an installed thrust or lift-weight ratio of 1.05 at zero airspeed with a neutral center of

FIGURE 1-5



gravity location (i.e., coincident thrust center and center of gravity). Installed lift includes all installation losses and aero-propulsion induced effects.

The mission breakdown of speed, fuel used, distance and time is presented in Figure 1-6.

Surface Attack Aircraft

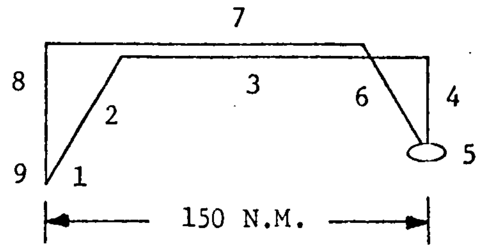
The missionized Surface Attack (SA) aircraft wing area and aspect ratio was established by the iterative process previously described for the ASW aircraft. The reduced mission loiter time (2.0 hours vs 4.0 hours) relative to the ASW mission permits a lower aspect ratio selection. The basic requirements are a 2-hour loiter TOS at 20,000 ft altitude and a 5-minute combat fuel allowance (20,000 ft, intermediate thrust, M = 0.8) at a 300 nm radius with a loading of two Harpoons and two AIM-9 missiles. Takeoff and other conditions were as defined for the ASW aircraft. Figure 1-7 presents the missionized SA performance of TOS versus radius of operation. The mission requirement is satisfied at a STOGW of 34,600 lb with an internal fuel loading of 11,993 lb; fuel loading is constant for the TOS variation with radius which depicts the interchange of loiter fuel for radius. The mission breakdown at 300 nm is shown by Figure 1-8.

Surveillance Aircraft

The missionized Surveillance (SURV) aircraft geometry, per the iterative process, includes three existing J97 gas generators (70 lb/sec) to satisfy the engine out VL condition without compromise. A two gas generator configuration could not fulfill the VL requirement within the permissible growth of the J97 gas generator (86 pound per second mass flow maximum) since the mission equipment weights, all non-disposable, increase the operating weight empty beyond the two gas generator capability. The third engine is operational only in the powered lift takeoff and landing phases of flight; cruise and loiter are accomplished with two gas generator operation. Mission equipment includes a 12 foot diameter rotodome antenna mounted on a telescoping strut under the fuselage between the main landing gear struts. A rotodome rather than a phased array configuration with its aerodynamic advantages was selected to provide improved radar effectiveness. Preliminary wind tunnel tests of various rotodome configurations indicated this location beneath the fuselage offers the minimum aerodynamic interference effects while retaining the T-tail empennage design. A negative installation angle of approximately 2.5 degrees was selected to provide ground clearance and reduce the aerodynamic interference effects of the rotodome with the aircraft. Analyses showed the aerodynamic contribution of the rotodome in this below fuselage position to be primarily an additional profile drag. The rotodome lift, centered approximately at 15 percent diameter, contributes a small destabilizing pitching moment for the installation selected in this design study.

The loiter TOS of four hours, the same as for the ASW mission, is less demanding because of the greater loiter altitude. Other mission conditions are the same as for the ASW aircraft except that the disposable load is zero and the STO deck run required to accomplish the mission is under 200 ft as a result of the three gas generator configuration dictated by the engine out VL criterion. The SURV aircraft mission performance is presented as TOS versus radius in Figure 1-9. The mission breakdown is presented in Figure 1-10.

FIGURE 1-6
MISSION BREAKDOWN - ASW (MISSIONIZED)



MISSION SEGMENT	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
STOGW 400 Ft Deck Run, 10 Kt Wod	42,900					
1) Warmup, T.O., Accel. to V_C 2 Min. Intermed. + 1/2 Min. T.O. Thrust		S.L.	-	530	-	0.042
	42,370					
2) Climb: To BCAV at Int. Thrust		36,089	0.61	1,040	50	0.137
	41,330					
3) Cruise: To Radius at BCAV			0.72	805	100	0.244
	40,525					
4) Descend: To 10,000 Ft, No Credit (Drop Tanks = 485 Lb)		10,000	-	-	-	-
5) Loiter: Best Endurance Speed		10,000	0.34	11,840	-	4.100
	28,200					
6) Climb to BCAV, Intermed. Thrust		36,089	0.63	437	23	0.062
	27,763					
7) Cruise to Starting Point, BCAV		36,089	0.66	756	127	0.336
	27,007					
8) Descend: To Sea Level, No Credit			-	-	-	-
	27,007					
9) Landing Allowance, Reserves:		S.L.				
10 Min Loiter, Best End. S.L.			.25	476	-	0.167
5% Total Initial Fuel			-	836	-	-
TOTAL				16,720	300	5.09

Notes: (1) 5 percent fuel flow tolerance included.
(2) Two gas generator operation, all mission segments.

FIGURE 1-7

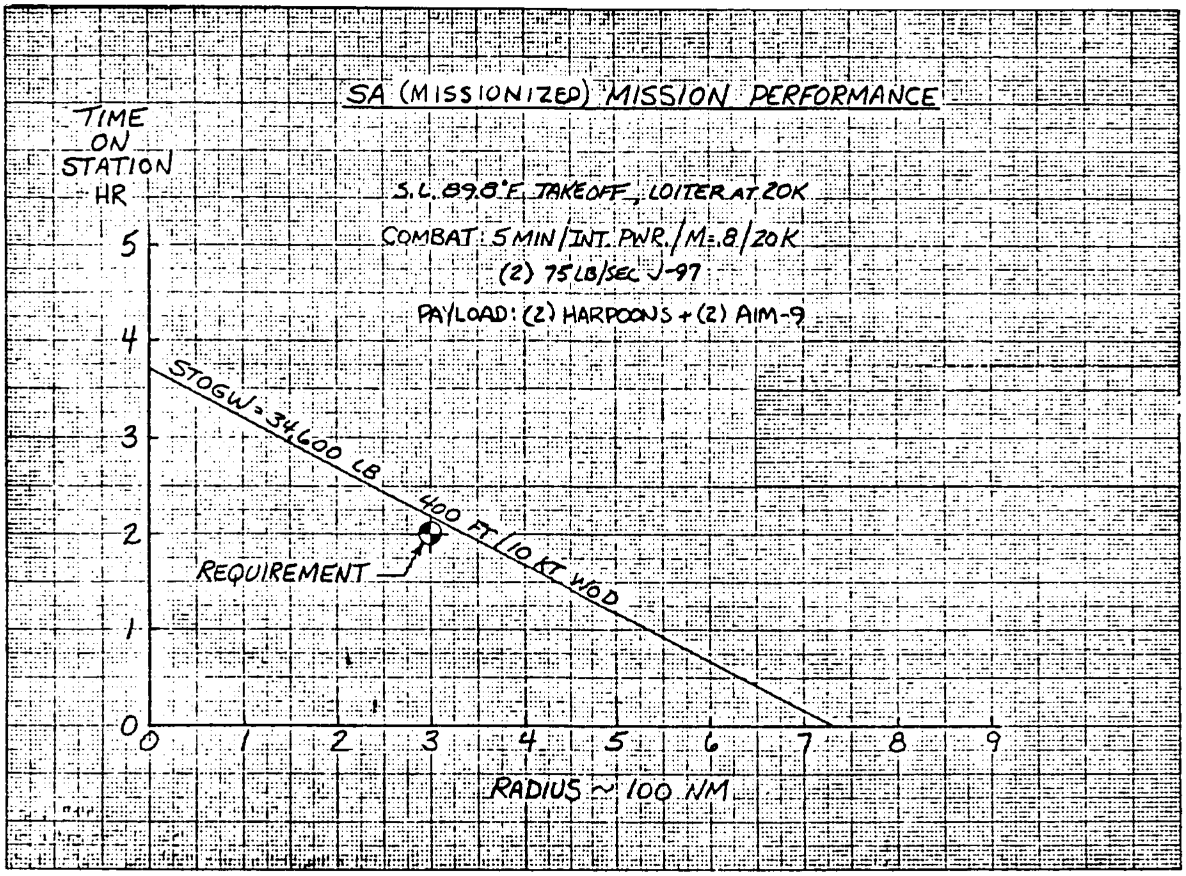
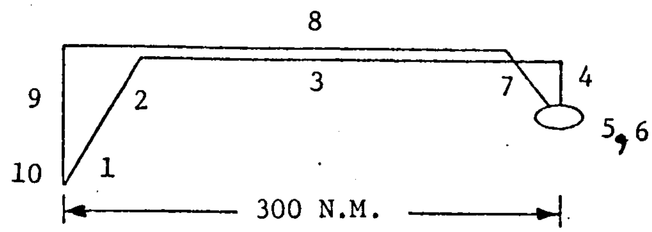

SA (MISSIONIZED) MISSION PERFORMANCE
S.L. 89.8°F TAKEOFF, LOITER AT 20K
COMBAT: 5 MIN/INT. PWR./M=.8/20K
(2) 75 LB/SEC J-97
PAYLOAD: (2) HARPOONS + (2) AIM-9
TIME ON STATION HR
STOGW = 34,600 LB
400 FT/10 KT WOD
REQUIREMENT
RADIUS ~ 100 NM
0
1
2
3
4
5
6
7
8
9

FIGURE 1-8
MISSION BREAKDOWN - SA (MISSIONIZED)



MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	34,600					
1) Warmup, T.O., Accel to V_{Climb} 2 Min Interm. + 1/2 Min T.O. Thrust			-	467	-	0.042
	34,133					
2) Climb: To BCAV at Intermed. Thrust			0.63	851	48	0.126
	33,282					
3) Cruise: To Radius at BCAV (Drop Tank when Empty)		36,089	0.73	1,735	252	0.602
	31,208					
4) Descend: To 20,000 Ft, No Credit				-	-	-
	31,208					
5) Loiter: 2 Hrs at 20,000 Ft Required		20,000	0.45	5,364	-	2.192
	25,844					
6) Combat: 5 Min at Intermed. Pwr. 20,000 Ft., M = 0.8		20,000	0.80	682	-	0.083
	25,162					
7) Climb: From 20,000 Ft to BCAV Intermediate Thrust			0.68	261	19	0.047
	24,901					
8) Cruise: Return at BCAV		36,089	0.70	1,573	281	0.701
	23,328					
9) Descend: To Sea Level, No Credit			-	-	-	-
	23,328	S.L.				
10) Landing Allowance and Reserves:						
10 Min Loiter Best End		S.L.	0.27	460	-	0.167
5% Total Initial Fuel			-	600	-	-
	22,268					
TOTAL				11,993	600	3.950

Note: 5% fuel flow tolerance included.

FIGURE 1-9

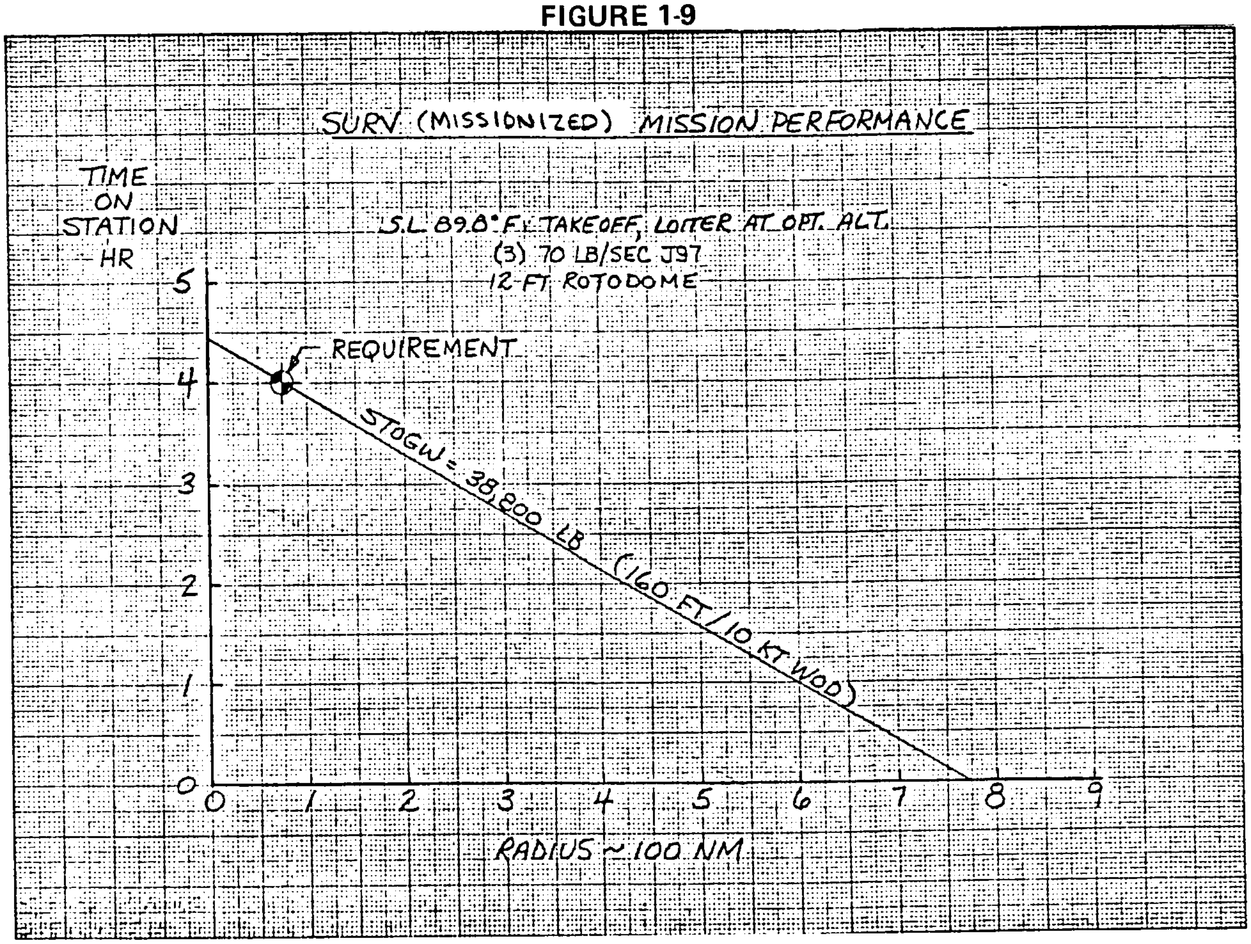
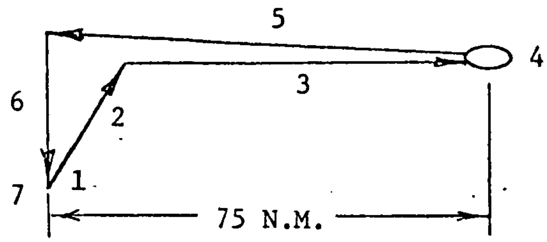

SURV (MISSIONIZED) MISSION PERFORMANCE
TIME ON STATION HR
S.L. 89.8° F TAKEOFF, LOITER AT OPT. ALT.
(3) 70 LB/SEC J97
12-FT ROTODOME
REQUIREMENT
STOGW = 38,800 LB (160 FT/10 KT WOD)
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
RADIUS ~ 100 NM

FIGURE 1-10
MISSION BREAKDOWN - SURV (MISSIONIZED)



MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
1) Warmup, T.O., Accel to V_{Climb} 2 Min. Intermed. + 1/2 Min T.O.	38,800 38,154		-	645	-	0.042
2) Climb: To BCAV at Intermed. Thrust	36,914		0.58	1,240	73	0.210
3) Cruise: To Radius at BCAV	36,897	36,089	0.72	17	2	0.005
4) Loiter: On Station (4) Hrs at Best Endurance 25,000 Ft or Higher	26,447	35,000	0.60	10,450	-	4.000
5) Cruise: To Point of Takeoff BCAV	25,957	36,089	0.67	490	75	0.195
6) Descend: To Sea Level, No Credit	25,957	S.L.	-	-	-	-
7) Landing Allowance and Reserves						
10 Min Loiter, Best End.		S.L.	0.27	480	-	0.167
5% Total Initial Fuel	24,777	-	-	700	-	-
TOTAL				13,982	150	4.619

Note: 5 percent fuel flow tolerance included.

Combat Search & Rescue Aircraft

The missionized Combat Search and Rescue (CSAR) aircraft geometry was selected to provide radius and midpoint hover capabilities plus low altitude dash performance rather than extended loiter time on station. Wing loading was increased and aspect ratio was reduced to improve high speed dash qualities and VTO useful load. Midpoint hover for rescue pickup was the prime input to gas generator size selection; the fallout initial takeoff and emergency VL performance are better than the mission specified levels. The initial takeoff gross weight was limited as a function of radius to levels that permitted midpoint arrival weight equal to hover capability using intermediate dry thrust rating (Hover GW = STOGW - Takeoff, Climb, Cruise Out, Loiter and Dash Out Fuels). The hovering rescue time was of primary importance to return to base distance; the number and weight of evacuees were not significant except as they influence hoisting time.

The mission performance as well as the initial takeoff gross weight limit defined by midpoint hover capability is presented in Figure 1-11. Three hover time periods are given; the initial 10 minutes of hover reduces the radius of action some 230 nm, the second 10-minute period some 200 nm since the gross weight level (and thus the fuel used) is reduced. The mission includes 20 minutes of loiter at optimum altitude prior to the sea level dash of 50 nm. Loiter TOS can be extended through the use of greater takeoff gross weights and distances. For example, the takeoff distance with 10 kt WOD is less than 200 ft for the 33,300 lb TOGW required to meet the specified mission. The STO criterion of the study, 400 ft 10 kt WOD, would permit a STOGW of 38,000 lb and a delta fuel of 4215 lb which would extend the pre-dash loiter time to 1 1/2 hours while retaining the midpoint hover capability. The mission breakdown for the specified mission is shown in Figure 1-12.

FIGURE 1-11

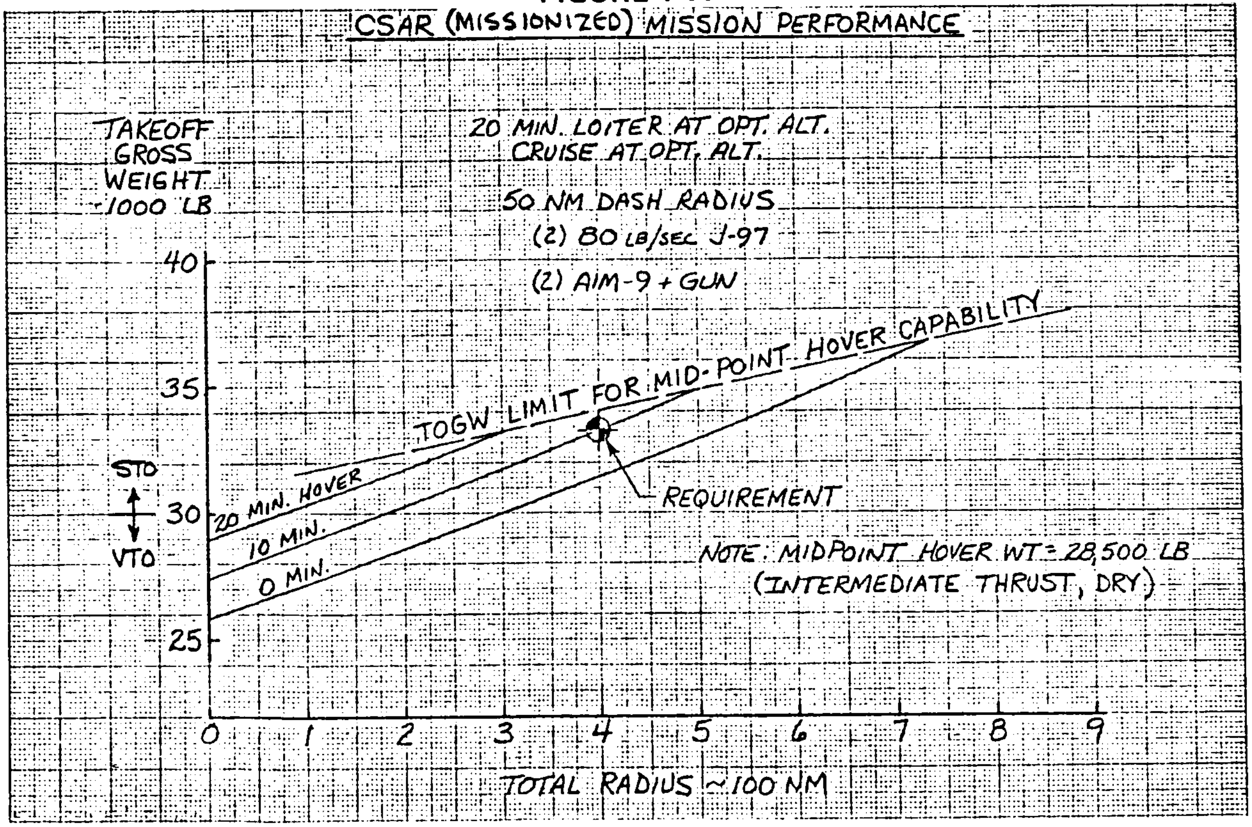
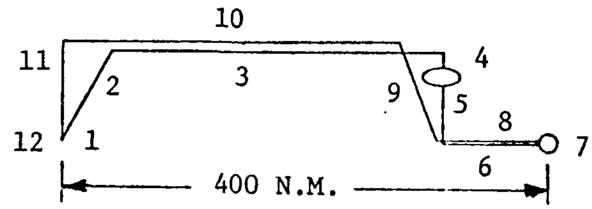


FIGURE 1-12
MISSION BREAKDOWN - CSAR (MISSIONIZED)



MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	33,300					
1) Warmup, T.O., Accel to V_{Climb} 2 Min Intermediate + 1/2 Min T.O.	32,800			500	-	0.042
2) Climb: To BCAV at Intermed. Thrust	32,036		0.66	764	42	0.104
3) Cruise: To 350 NM at BCAV	29,812	36,089	0.74	2,224	308	0.727
4) Loiter: 20 Min at Opt/Alt Best End	28,920	35,000	0.65	892	-	0.333
5) Descend: To Sea Level, No Credit	28,920			-	-	-
6) Dash: 50 NM at Sea Level, M = 0.8	27,840	S.L.	0.77	1,080	50	0.098
7) Hover: 10 Min at S.L. (OGE) Pick-Up 400 lb.	26,640	S.L.	0.00	1,600	-	0.167
8) Dash: 50 NM at Sea Level M = 0.8	25,560	S.L.	0.77	1,080	50	0.098
9) Climb: To BCAV at Intermed. Thrust	25,035		0.64	525	27	0.071
10) Cruise: At BCAV to Point of Takeoff	23,123	36,089	0.72	1,912	323	0.784
11) Descend: To Sea Level, No Credit	23,123			-	-	-
12) Landing Allowance and Reserves:						
10 Min Loiter Best Endurance		S.L.	0.29	500		0.167
5% Total Initial Fuel				585		-
TOTAL	(22,038)			11,662	800	2.591

Note: 5 percent fuel flow tolerance included

Vertical On Board Delivery Aircraft

The missionized Vertical On Board Delivery (VOD) aircraft geometry was iterated to give the minimum size that fulfills the mission requirements for radius, payload, cargo, and length/volume. The OWE plus 1000 lb of fuel and the passenger weight establishes the emergency engine out VL capability as the design criterion for gas generator sizing. As for SURV point design aircraft, three existing J97-GE gas generators (70 lb/sec) were selected since two maximum growth airflow generators (85 lb/sec) are incapable of fulfilling the VL requirement. Wing parametric study results from the technology data base showed VOD range performance to be improved by aspect ratio increase up to six. The missionized VOD wing aspect ratio is 5.7 which compromises the range slightly in favor of greater wing internal fuel capacity and lower wing fold weight penalty. The VTO gross weight wing loading, the aerodynamic reference base, is 86.4 lb/sq ft. At the mission STOGW of 44,800 lb, the W/S is 112 lb/sq ft. The effect of wing loading or wing area on aircraft short takeoff capability is discussed in Section 3.2.

The mission performance, Figure 1-13, shows 5000 lb of disposable payload can be transported 2000 nm with an initial STO well within the permissible 450 ft deck roll, 20 kt WOD criterion. As range is reduced the payload may be increased per the variation shown or as restricted by cargo bay size or floor strength. A 16,000 lb payload can be transported over a radius of 400 nm, a standoff distance typical for Marine Combat Support from Naval ships. Figure 1-14 presents the effect of removing the 36,089 ft cruise altitude restriction, and permitting operations at the optimum altitude established by the input aerodynamic and propulsion data. For the specified 5000 lb payload, the range is extended 6.5% to 2110 nm. The VOD mission breakdown with the 36,089 ft altitude restriction is presented by Figure 1-15. The specified design mission of 2000 nm can be accomplished in about 5.3 hours. The fuel allowance for warmup, takeoff, and acceleration to wingborne flight climb velocity was determined for three gas generator operation; the remaining allowances are for two gas generator operation. The loiter portion of the landing reserves was doubled to a 20-minute time period relative to that for a radius mission.

FIGURE 1-13

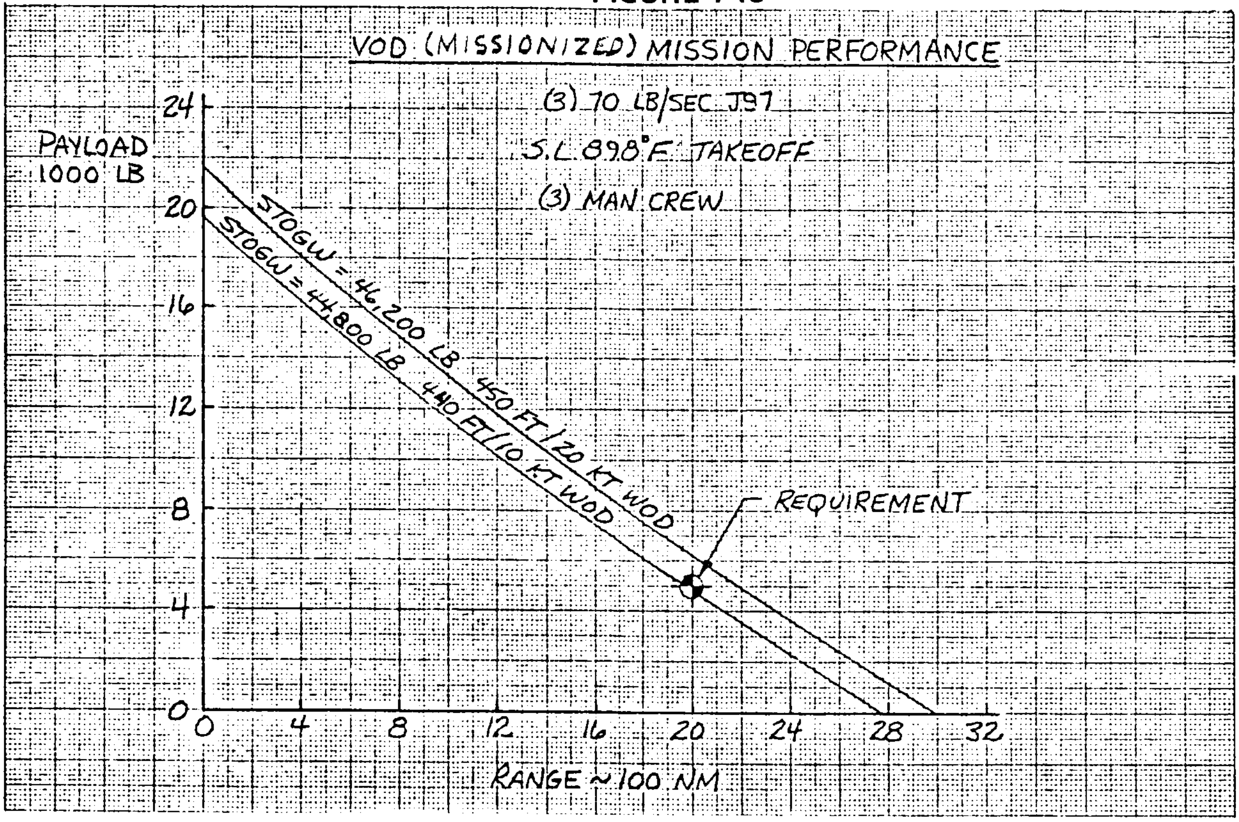


FIGURE 1-14

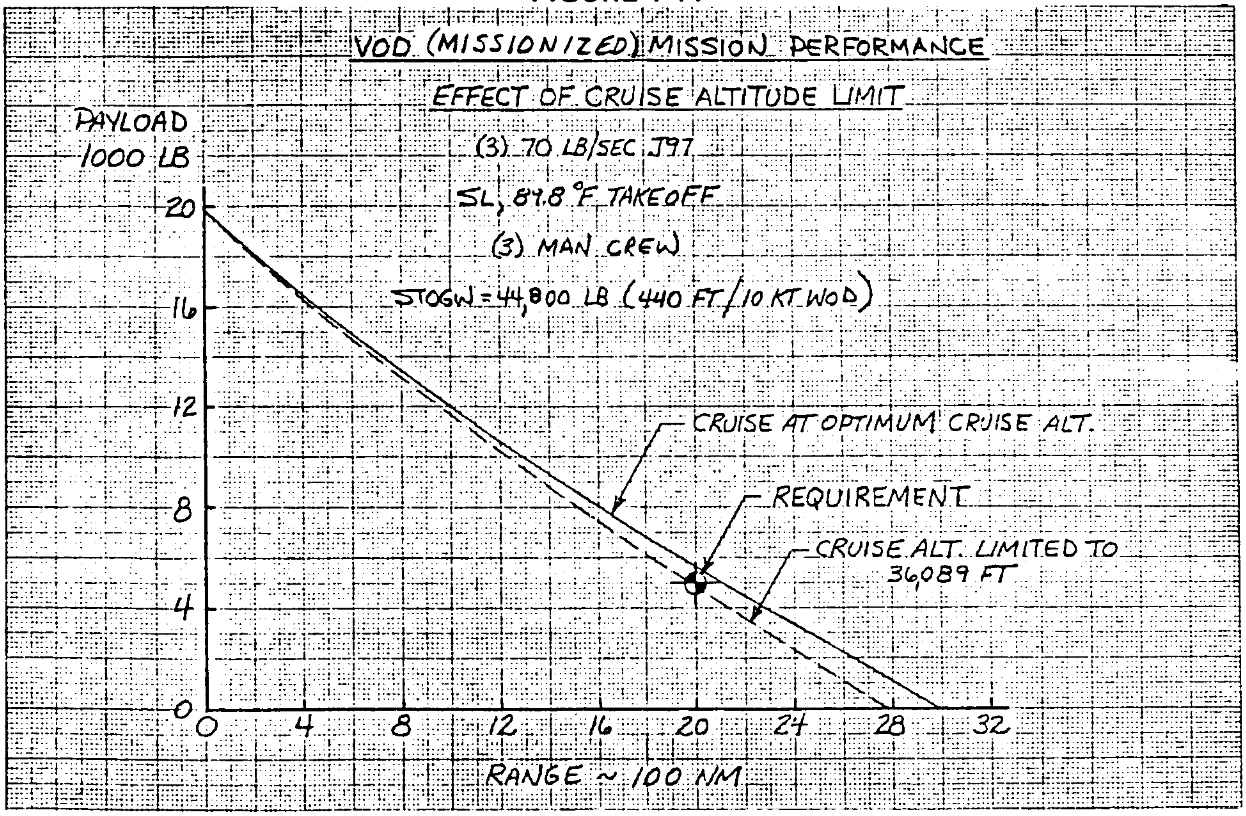
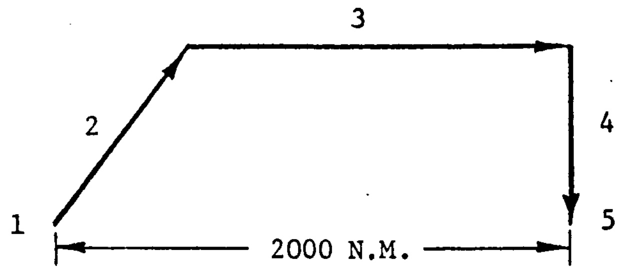


FIGURE 1-15
MISSION BREAKDOWN - VOD (MISSIONIZED)



MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	44,800					
1) Warmup, T.O., Accel to V_{Climb}			-	645	-	0.042
2 Min Interm +						
1/2 Min T.O.	44,155	S.L.				
2) Climb: To BCAV at Intermed.			0.61	1,400	88	0.240
Thrust	42,755	35,160				
3) Cruise: BCAV			0.72	13,904	1912	4.630
	28,851	36,089				
4) Descend: To Sea Level,				-	-	-
No Credit	28,851	S.L.				
5) Landing Allowance and Reserves:						
20 Min Loiter, Best Endurance				1,193	-	0.333
5% Total Initial Fuel				902		
	26,756					
TOTAL				18,044	2000	5.25

Note: 5 percent fuel flow tolerance included.

1.3 PROPULSION

The basic propulsive/lift system for each of the missionized aircraft consists of three turbotip fans, interconnected through the Energy Transfer and Control (ETaC) system to turbojet gas generators. Specifically, the J97-GE-100/LF459 was used as the reference gas generator/fan cycle. The J97-GE-100 is a single-spool turbojet with 14-stage compressor, annular combustor, and two-stage turbine. The single-stage LF459 fan with design technology similar to the LF460, is driven by a single-stage tip turbine having a turbine discharge pressure ratio (TDPR) = 1.30. The LF459 is designed to produce a fan pressure ratio (FPR) of 1.32 at 100% rpm at static standard S.L. conditions.

Individual aircraft were designed utilizing the J97/LF459 systems or growth derivatives to perform the five specific Navy missions. The approach used involved determination of a credible growth derivative of the J97 engine to establish a range of gas generator sizes while retaining the near-term availability associated with the basic J97-GE-100 technology level. Several means of achieving J97 growth were explored with General Electric Co., including; (a) increased turbine inlet temperature, (b) flared compressor, and (c) addition of a zero compressor stage. The growth derivative performance was based on the flared compressor approach after making a detailed cycle match and performance estimate to establish feasibility. General Electric confirmed the reasonableness of this approach and the performance estimates.

The resulting propulsion systems for the missionized aircraft incorporate either two or three gas generators, Figures 1-16 and 1-17, powering three turbotip fans. The third gas generator is necessary to provide adequate power for emergency vertical landing at OWE plus 1000 lb of fuel for the SURV aircraft, and, OWE plus 1000 lb of fuel and a 5000 passenger load for the VOD aircraft, following failure of one of the gas generators.

Gas Generator/Fan Size

Gas generator and fan sizes were allowed to vary as required to meet the mission requirements but within limits commensurate with the maximum anticipated growth potential of the J97-GE-100 engine. Two levels of performance were established:

- o J97-GE-100/LF459 - 70 lb/sec current engine
- o J97 (XX)/LF459 - 80 lb/sec growth engine

Characteristics of the gas generators are summarized in Figure 1-18. The fixed J97-GE-100/LF459 baseline level of performance was derived from GE performance computer program Reference (1), and, MCAIR fan performance computer program Reference (2). The J97 (Growth)/LF459 level of performance corresponds to the performance of a flared compressor modification to the J97 which results in an estimated 80.3 lbs/sec airflow rate. In addition to the flared compressor growth concept, G.E. offered a zero stage addition to the compressor as an alternative means of achieving growth, up to an airflow rate of 86 lbs/sec (23% increase). Therefore, the 80.3 lbs/sec J97 (Growth)/LF459 level of performance was scaled up or down to suit the missionized aircraft requirements except that a maximum size (airflow rate) limit was set at 1.23 times the J97/GE-100 giving 86 lbs/sec as the

FIGURE 1-16
PROPULSION SYSTEM ARRANGEMENT
2 Gas Generators/3 Fans

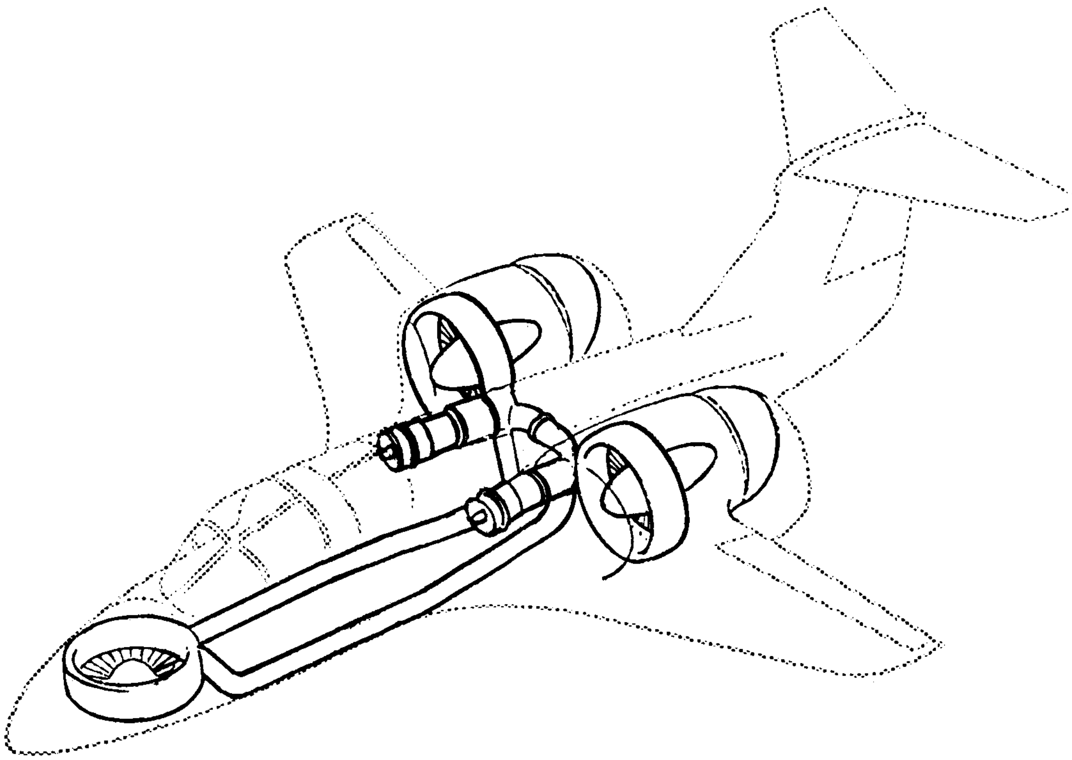
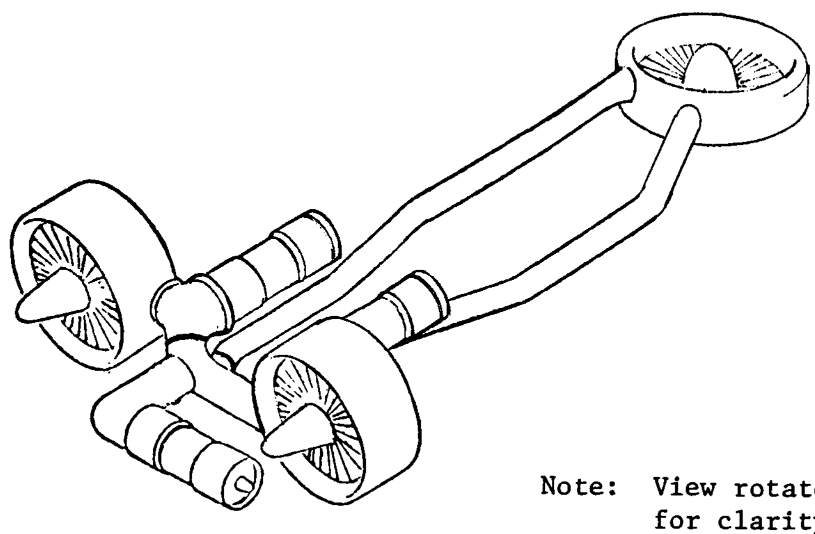


FIGURE 1-17
PROPULSION SYSTEM ARRANGEMENT
3 Gas Generators/3 Fans



Note: View rotated 180° for clarity

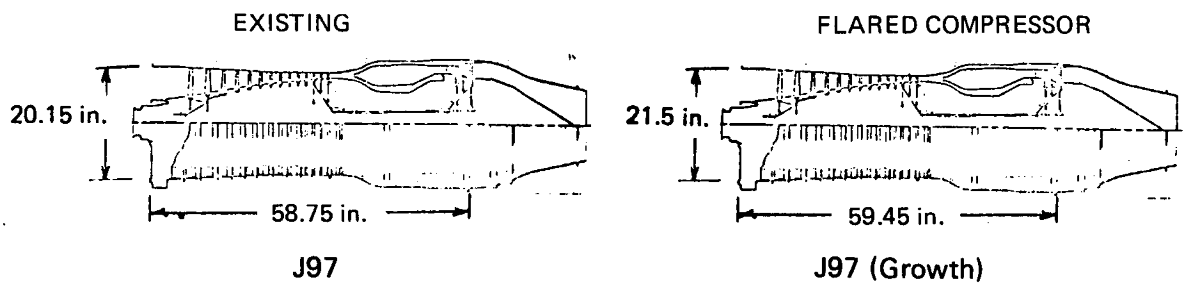
anticipated growth limit. To obtain a physical size corresponding to the performance (airflow rate) size, the following scaling rules were applied:

$$\text{Gas Generator Dia.} = \left(\frac{(W_A)_{Req'd}}{80}\right)^{1/2} \times 21.5$$

$$\text{Fan Diameter} = \left(\frac{(W_A)_{Req'd}}{80}\right)^{1/2} \times 59$$

where 70 lbs/sec < $(W_A)_{Req'd}$ < 86 lbs/sec

FIGURE 1-18
GAS GENERATORS



	Characteristics	
70.0 lb/sec	Design Airflow	80.3 lb/sec
14.1	Compressor Pressure Ratio	16.4
2040°F	Turbine Inlet Temperature	2070°F
1375°F	Exhaust Gas Temperature	1375°F
5270 lb	Engine Dry Thrust	6140 lb
739 lb	Engine Dry Weight	789 lb
7.3	Thrust/Weight	7.8

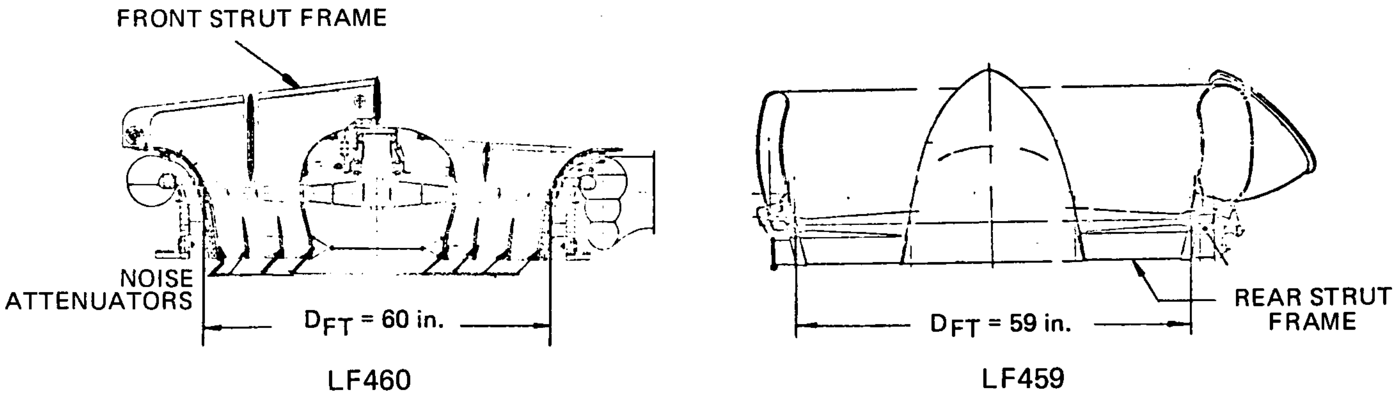
Figure 1-19 compares the characteristics of the LF459 with those of the LF460. Design improvements include moving the support strut/frame to the downstream side of the fan and reshaping the scroll cross section to suit an inlet/nacelle installation. The LF459 is estimated to be a net 89 lb lighter than the LF460. Deletion of noise attenuation material, no need for anti-icing (no inlet struts), and a one-inch smaller diameter contributed to weight reduction whereas an additional weight allowance was made for a continuous duty lubrication system and blade strength to sustain bird strikes.

Fan Thrust Vectoring Nozzles and Thrust Spoilers

The lift and lift/cruise fans are each fitted with thrust vectoring nozzles and thrust spoilers. Fore and aft thrust direction is mechanically controlled during vertical takeoff through transition to wingborne flight. Thrust is also vectored sideways for yaw control during the powered lift mode. Thrust spoilers reduce the thrust component as required at any one of the three fans during energy transfer for pitch or roll control.

A

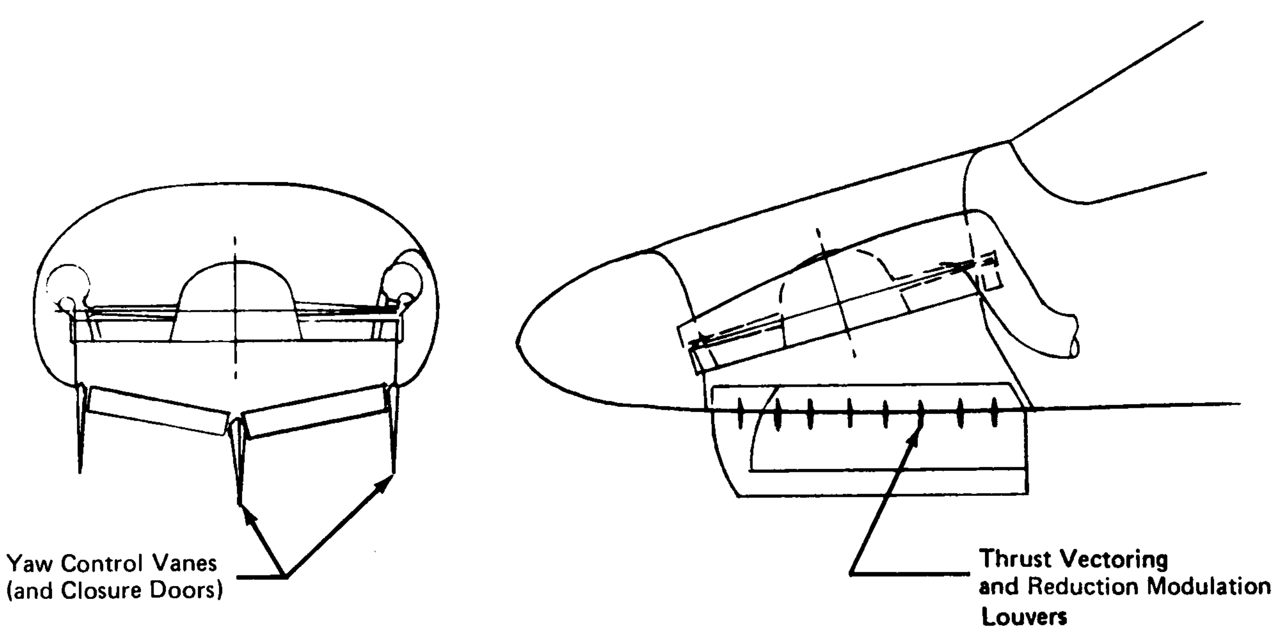
FIGURE 1-19
FAN COMPARISON
LF460 - LF459



Fan Characteristics	LF460	LF459
Fan Pressure Ratio/TDPR	1.35/1.13	1.32/1.30
Airflow (lb/sec)	617	624
Thrust (lb)	15,050	16,310
Weight (lb)	789	700
Thrust/Weight	19.1	23.3

The lift fan (nose) thrust vectoring system is shown in Figure 1-20. A set of louvers vectors thrust fore and aft, and yaw vanes are used to vector thrust sideways. These vanes also function as closure doors after transition to wingborne flight. The fan is tilted forward 15° for improved air inlet performance and to reduce the amount of thrust vectoring required.

FIGURE 1-20
FORWARD FAN VECTORING SYSTEM



A

Figure 1-21 shows the lift/cruise fan thrust vectoring nozzle concept. Rotating hood segments vector thrust fore and aft and vanes vector thrust sideways for yaw control. A thrust spoilage port in each nozzle reduces thrust as required during roll or pitch control applications. The yaw vanes close during wingborne flight.

Figure 1-22 tabulates the missionized aircraft propulsion system characteristics.

FIGURE 1-21
LIFT/CRUISE THRUST VECTORING SYSTEM

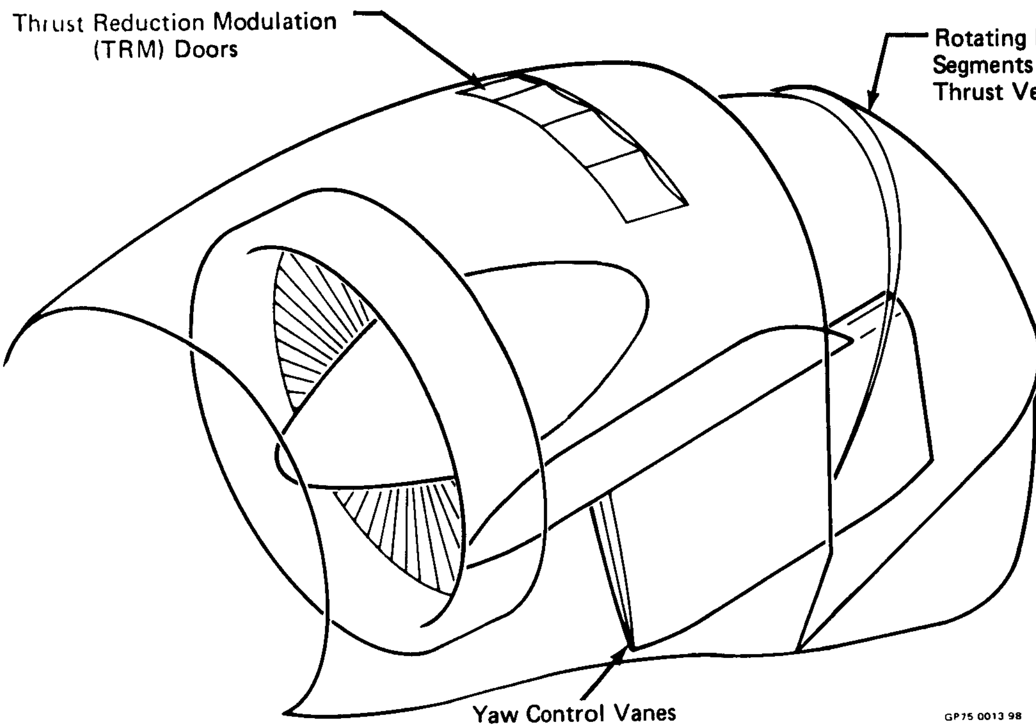


FIGURE 1-22
MISSIONIZED AIRCRAFT PROPULSION SYSTEMS

	ASW	SA	SURV	CSAR	VOD
Gas Generators					
No. of Gas Generators	2	2	3	2	3
Airflow - lb/sec	86	75	70	80	70
Fans					
Number of Fans	3	3	3	3	3
Diameter - in.	61	57	59	59	59
Pressure Ratio	1.32	1.32	1.32	1.32	1.32

1.4 AVIONICS

Considerable study, analysis, and review of avionics systems for the multi-purpose V/STOL aircraft have taken place over the past several years, with numerous visits made to government agencies and avionics equipment suppliers. "Subsystem Payloads", Appendix A of Report A-503-74-2, provided by the Navy at the 18 October 1974 coordination meeting, was reviewed and compared with previous and on-going studies to determine appropriate equipment for each of the missionized aircraft. Further coordination discussions were held with the Advanced Systems Division of NAIR-503 concerning the rationale for general equipment selection.

A detailed equipment listing was prepared for each of the five missioned aircraft and is presented in Figure 1-23. A strong attempt was made to have the same specified avionic equipment in a given category for each of the five missions. The equipment listed allows autonomous operations, utilizing advanced technology in the key areas of specialized sensors, processing and display, while retaining low cost conventional equipment for the more routine functions such as communication and navigation.

ASW and Surveillance Missions Avionics

Figures 1-24 and 1-25 compare both guideline and selected equipment weights for the ASW and Surveillance missions, respectively. For each functional category, the principal pieces of equipment are enumerated. Considerable agreement occurs between "guideline" and "selected" in the ASW avionics with the exception of the "Acoustic Subsystem", where a more advanced sonobuoy receiver and acoustic analyzer were selected, and "Non-Acoustic Sensors", where FLIR and Electronic Support Measures avionics were added to the ASW radar and MAD. Again, fairly close agreement is shown for "guideline" and "selected" avionics in the Surveillance case, with a larger data link system (modems and cryptos) in the "CNI" area, and a higher performance surveillance radar in "Sensors" being selected for the missionized study aircraft.

The most important avionics equipment associated with the Surveillance aircraft is its radar system. The overriding consideration is that the radar system must detect the triad of possible threats - large bombers, anti-shipping missiles, and both small and large surface targets at reasonable distances. Fundamental mission requirements also dictate a 360 degree coverage with this long range detection and tracking. Several alternative approaches were investigated considering various antenna sizes and installations to determine their effectiveness in satisfying these mission requirements. Figure 1-26, compares specific performance against a 10 square meter target for seven antenna configurations studied: two phased array systems, two rotating flat-faced array systems, and three rotodome antennas. The curves clearly show the performance superiority of the rotodome antennas. The performance variation as a function of azimuth angle for the phased array configurations is characteristic of that type of antenna because the gain is reduced from the broadside maximum as it is electronically scanned. The 12 foot diameter dome size that was selected is a compromise between detection range and aircraft performance, but represents a substantial improvement over both versions of phased arrays and over the 8 foot diameter rotodome.

FIGURE 1-23
AVIONICS EQUIPMENT SUMMARY
Numbers Indicate Uninstalled Weight in Lb

EQUIPMENT	NOMENCLATURE	ANTI-SUBMARINE WARFARE (ASW)	SURFACE ATTACK (SA)	VERTICAL ONBOARD DELIVERY (VOD)	SURVEILLANCE	COMBAT (STRIKE) SEARCH & RESCUE (CSAR)
RADAR						
RADAR (12 FT ROTODOME)	NEW				3407	
ASW RADAR	APS-116	450				
SURFACE SEARCH RADAR	NEW		132			
WEATHER RADAR	AVQ-21A			52		52
SUBTOTAL		450	132	52	3407	52
COMM, RADIO NAV, IDENT						
UHF AM VOICE RADIO (2)	ARC-156	74	74	74	74	74
HF SSB RADIO	718U	46	46		46	
UHF VOICE CRYPTO	KY-28/TSEC	16	16	16	16	16
HF VOICE VOCODER	HY-8	35	35		35	
HF CRYPTO	KG-35	20	20		20	
UHF DATA LINK	ASW-25	13.4	13.4	13.4	13.4	13.4
DATA LINK - LINK 11					155	
INTERCOMM	AIC-14	23	23	15	23	15
UHF ADF	OA8639	11.4	11.4	11.4	11.4	11.4
TACAN	ARN-84(V)	32	32	32	32	32
OMEGA	ARN-99				58	
IFF TRANSPONDER	APX-100	6.5	6.5	6.5	6.5	6.5
IFF INTERROGATOR	APX-76		47.8		47.8	
IFF CRYPTO	KIT-1A/TSEC	12	12	12	12	12
IFF CRYPTO	KIR-1A/TSEC		15.5		15.5	
SUBTOTAL		289.3	352.6	180.3	565.6	180.3
NAVIGATION						
INERTIAL NAVIGATION SYSTEM	ASN-92	81.2	81.2	81.2	81.2	81.2
ATTITUDE AND HEADING REFERENCE	ASN-107	35.1	35.1	35.1	35.1	35.1
DOPPLER NAVIGATOR	NEW	28	28	28	28	28
NAVIGATION PROCESSOR	NEW	40	40	40	40	40
RADAR ALTIMETER	APN-194	7.3	7.3	7.3	7.3	7.3
AIR DATA COMPUTER	SK6 MOD	16.2	16.2	16.2	16.2	16.2
LOW VELOCITY AIRSPEED SYSTEM	J-TEC (2)	10.3	10.3	10.3	10.3	10.3
SUBTOTAL		218.1	218.1	218.1	218.1	218.1
ACOUSTIC SUBSYSTEM						
ACOUSTIC ANALYZER	PROTEUS	285				
SONOBUOY RECEIVER	NEW	40.6				
SONOBUOY REFERENCE	NEW	40				
ON TOP POSITION INDICATOR	R-1651	8				
AUXILIARY MASS STORAGE	NEW	30				
MAGNETIC TAPE RECORDER	NEW	40				
SUBTOTAL		443.6				
NON-ACOUSTIC SENSORS						
MAD DETECTOR (TOWED)	ASQ-81	164.3				
ELECTRONIC SUPPORT MEASURES	ALR-47	89	89			
PASSIVE DETECTION SYSTEM	ALR-59 MOD				412	
FLIR	NEW	150	150			
AUTO TRACKING SYSTEM	ACTRON					30
SUBTOTAL		403.3	239		412	30
DATA PROCESSING, CONTROL AND DISPLAY						
GENERAL PURPOSE COMPUTER	AP-101 TYPE	120	40		120	30
PILOT CONTROL	ASQ-147 TYPE	15.3	15.3		15.3	15.3
COPILOT CONTROL	ASQ-147 TYPE	15.3	15.3		15.3	15.3
SENSO CONTROL	ASQ-147 TYPE	25.3				
TACCO CONTROL	ASQ-147 TYPE	25.3				
SEARCH STORES CONTROL	NEW	15				
ARMAMENT CONTROL	NEW	46	46			46
PILOT INDICATOR	ASA-82 TYPE	47.5	47.5	15	47.5	15
COPILOT INDICATOR	ASA-82 TYPE	47.5	47.5		47.5	
SENSO INDICATOR	ASA-82 TYPE	67				
ACOUSTIC INDICATOR	ASA-82 TYPE	23				
TACCO INDICATOR	ASA-82 TYPE	67				
DISPLAY GENERATOR	NEW	80	50	20	50	20
SCAN CONVERTER	NEW	30	30			
RADAR/COMMAND SITUATION DISPLAYS (2)	APA-172 TYPE				450	
SUBTOTAL		624.2	291.6	35	745.6	141.6
AUTOMATIC LANDING SYSTEM						
ACLS BEACON X-BAND	APN-202	7.9	7.9	7.9	7.9	7.9
ACLS BEACON K_a BAND	R-1623	6.0	6.0	6.0	6.0	6.0
RECEIVER-DECODER GROUP	ARA-63	12.3	12.3	12.3	12.3	12.3
SUBTOTAL		26.2	26.2	26.2	26.2	26.2
TOTALS		2454.7	1259.5	511.6	5374.5	648.2

FIGURE 1-24
ASW AVIONICS

Functional Category	Equipment	Uninstalled Guideline	Equip Wt (lb) Selected
Navigation	Doppler, Attitude Systems, Air Data, Radar Alt	211	218
Communication, Radio Nav, Identification	UHF, HF Comm with Security, Data Link, Direction Finding, TACAN, Transponder	340	289
Acoustic Subsystem	Sonobuoy Rcvr, Reference, Acoustic Analyzer, Storage for 16 Channels	484	-
	32 Channels	785	444
Non-Acoustic Sensors	ASW Radar and MAD	507	614
	FLIR and ESM	-	239
Data Processing, Control, Display	Operator Displays, Controls, Display Generation, General Purpose Processors	535	624
Auto Landing System	X, K_a Band Beacons, Rcvr-Decoder Group	-	26
	Totals	2077/2378	2454

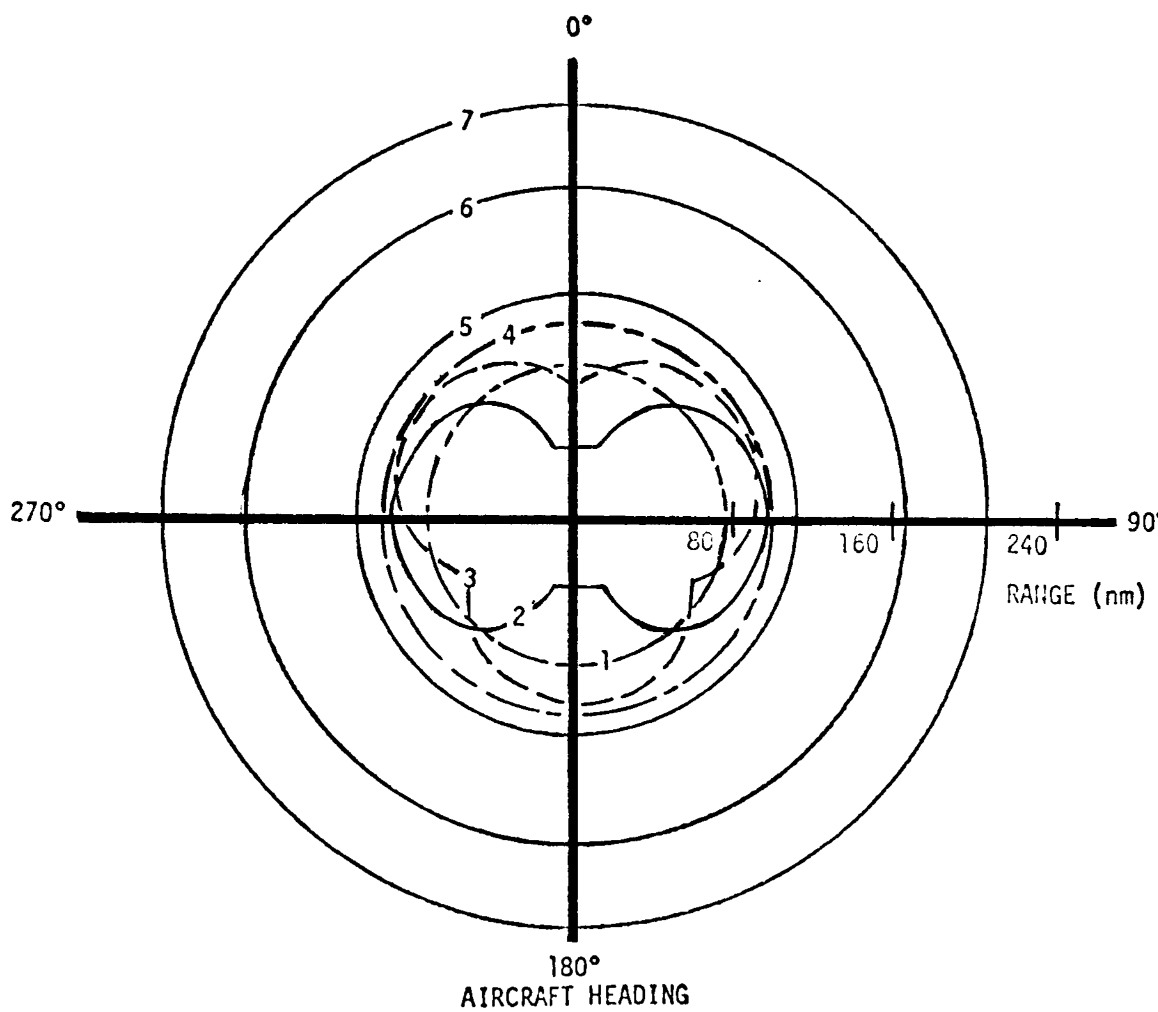
FIGURE 1-25
SURVEILLANCE AVIONICS

Functional Category	Equipment	Uninstalled Guideline	Equip Wt (lb) Selected
Navigation	Same as ASW	211	218
Communication, Radio Nav, Identification	Same as ASW	340	289
	Add Larger Data Link, Interrogator and Omega	-	277
Sensors	Surveillance Radar and Passive Detection System	1600 (2080/1.3)	3819
Data Processing, Control, Display	Same as ASW	535	-
	Same as ASW except Different Controls, Displays for Aft Operators	-	746
Auto Landing System	Same as ASW	-	26
	Totals	2686	5375

FIGURE 1-26
RANGE FOR 90 PERCENT PROBABILITY OF DETECTION

1 HSR-1 Radar
2 12 Ft Fin (Back-Back Arrays)
3 12 Ft Dome (Three Arrays)
4 HSR-1 Improved Radar
5 8 Ft Rotodome
6 12 Ft Rotodome
7 16 Ft Rotodome

Co-Altitude - 35,000 ft
Target Cross Section - 10 sq meters
Aircraft Velocity - 320 kts
Target Velocity - 712 kts (Radial)



As shown in Figure 1-26, two versions of the Westinghouse HSR-1 radar were considered--the existing system and a postulated improved system. Neither system has the performance of even the eight foot rotodome. The original HSR-1 radar was simply a prototype using a shipborne radar and had the following production disadvantages:

- The antenna is not protected by a radome and is therefore subject to weather, wind loading and rough handling which would cause deterioration and degradation. When in operation, the antenna limits even helicopter speed to about 70 knots.

- Height finding capability must be developed.

- Current design has limited detection range capability. Redesign is necessary to obtain the additional postulated range.

- Small surface target detection capability is questionable.

A development program would be required to solve these problems. The amount of development would be greater than that expected for frequency change and antenna alterations for the selected baseline surveillance radar, which would also have the required superior detection performance against the triad of anticipated threats.

In both the ASW and SURV avionics systems, the automatic landing system equipment was added.

Other Missions Avionics

A substantial part of the avionics systems for the other missions (SA, CSAR and VOD) is identical, with the same baseline navigation and automatic landing system equipment. Variations occur within these missions in the radar and other sensors, data processing and controls and displays, with some additional alterations within the CNI area.

The Surface Attack mission will normally be performed by a version of the aircraft which is assigned to general area search to maintain surveillance of surface activity, and includes the requirement to identify surface vehicles in addition to detecting them. The target characteristics of high radar cross section and high visual contrast can be exploited by the use of the surface search radar for long range detection and the FLIR system for closer range identification. Radar transmissions from the surface vehicles can also be intercepted by the Electronic Support Measures equipment carried on the aircraft. The SA mission avionics are the same as those for the ASW mission with the following exclusions: Acoustic Subsystem, MAD Detector, and TACCO and SENSO controls and displays. An IFF interrogator with crypto is added to aid in the identification process.

The CSAR and VOD avionics are very similar, both versions having significantly less avionics requirements than the other previously discussed missionized aircraft. Navigation and automatic landing system capabilities and characteristics are identical for both systems as with all of the other missions. In the CNI area, neither system has High Frequency communications transceivers and cryptos, although it would be possible to add them to the aircraft for only 46 pounds. The VOD aircraft displays consist only of the shared weather radar indicator and the head-up display, which requires its own symbol generator. No general purpose data processing is required for the VOD version, navigation computations taking place through a dedicated processor within that area. The CSAR aircraft also has the shared weather radar display and the HUD, but adds armament controls, a weapons release and interface processor, and operator controls to address the processor.

1.5 DESIGN

The five missionized aircraft designs reflect all the design guideline requirements, Appendix A. The key design parameters which influenced the designs of the missionized aircraft are as follows:

(a) Locations of the thrust center, center of gravity, and aerodynamic center.

(b) The spacing and locations of the fans.

(c) The stabilizer location.

(d) Mission payload, equipment, and fuel requirements.

(e) Wing geometry - area and aspect ratio.

The fan locations (and thrust centers) have a significant impact on lift and lift/cruise characteristics, thrust vectoring, control and moment trim, and wing induced lift and ground effects. The selection of these parameters as well as stabilizer location was based on MCAIR V/STOL aircraft technology base and wind tunnel test results.

The design criteria used for synthesis and sizing of the five missionized aircraft are summarized in Section 1.6. Aerodynamic and propulsion considerations are discussed in Sections 1.2 and 1.3 respectively. Brief descriptions of each configuration and associated design data are presented in the following paragraphs.

ASW (Missionized) Aircraft

Figure 1-27 shows the general arrangement and locations of mission equipment and payload. Figure 1-28 lists the principal weights and geometric characteristics of the ASW aircraft. The ASW aircraft has a crew of four and is equipped with the required avionic equipment. Mission load for the ASW aircraft consists of MK-46 torpedoes (2) carried under the fuselage, mixed sonobuoys (50), and MK-25 markers (8). Approximately 62% of the mission fuel required is carried in the wing, 22% in the fuselage, and the remainder in external tanks.

SA (Missionized) Aircraft

Figure 1-29 shows the general arrangement and locations of mission payloads and fuel. Figure 1-30 lists the principal weights and geometric characteristics of the SA aircraft. The aircraft accommodates a crew of three and is equipped with the required avionic equipment. Mission load for the SA aircraft consists of Harpoons (2) carried on inboard wing stations and AIM-9s (2) carried on outboard stations. All mission fuel is internal, with an equal distribution between wing and fuselage tanks.

SURV (Missionized) Aircraft

Figure 1-31 shows the general arrangement and locations of mission equipment and payload. The principal weights and geometric characteristics of the SURV aircraft are listed in Figure 1-32. The aircraft is designed to accommodate a crew of four and incorporates a 12-foot retractable rotodome on the bottom of the

FIGURE 1-27
GENERAL ARRANGEMENT
ASW Missionized Aircraft

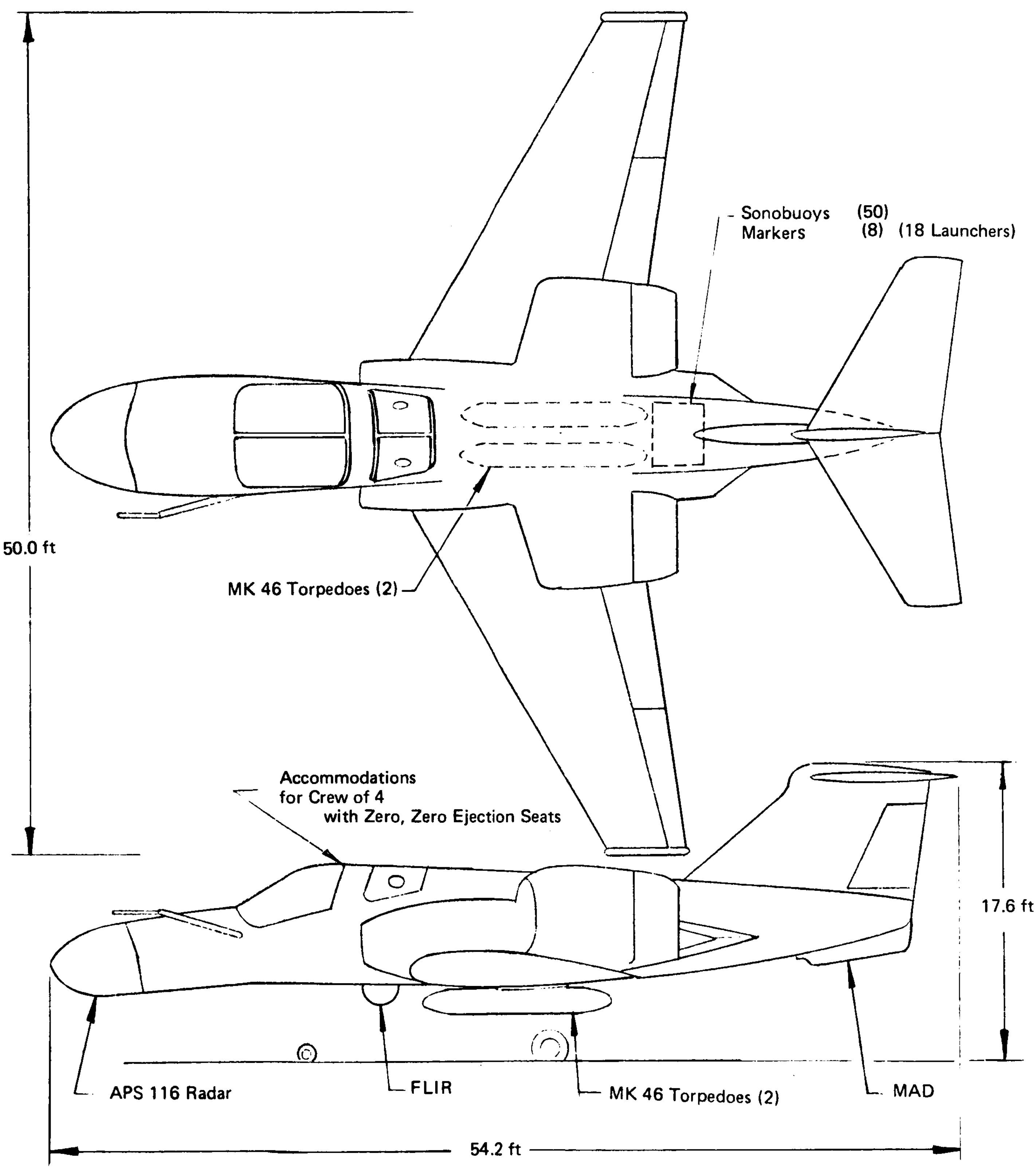


FIGURE 1-28
DIMENSIONAL AND DESIGN DATA
ASW Missionized Aircraft

STOGW	(lb) (N)	42,900 (190,820)
OWE	(lb) (N)	22,841 (101,596)
BFDGW	(lb) (N)	37,220 (165,554)
Overall Length	(ft) (m)	54.20 (16.52)
Wing Span	(ft) (m)	50.00 (15.24)
Wing Span (folded)	(ft) (m)	28.80 (8.78)
Height	(ft) (m)	17.60 (5.36)
Height (for stowage)	(ft) (m)	18.60 (5.66)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	500 (46.45)	120 (11.15)	70 (6.50)
AR	5.00	3.67	.69
λ	.30	.41	.49
b (ft) (m)	50.00 (15.24)	21.00 (6.40)	6.80 (2.07)
$\Lambda c/4$ (deg)	25.0	25.0	42.8
t/c % Root/Tip	17/8	10/8	10
Airfoil	Supercritical (Modified)	64_AXXX	64_AXXX

FIGURE 1-29
GENERAL ARRANGEMENT
SA Missionized Aircraft

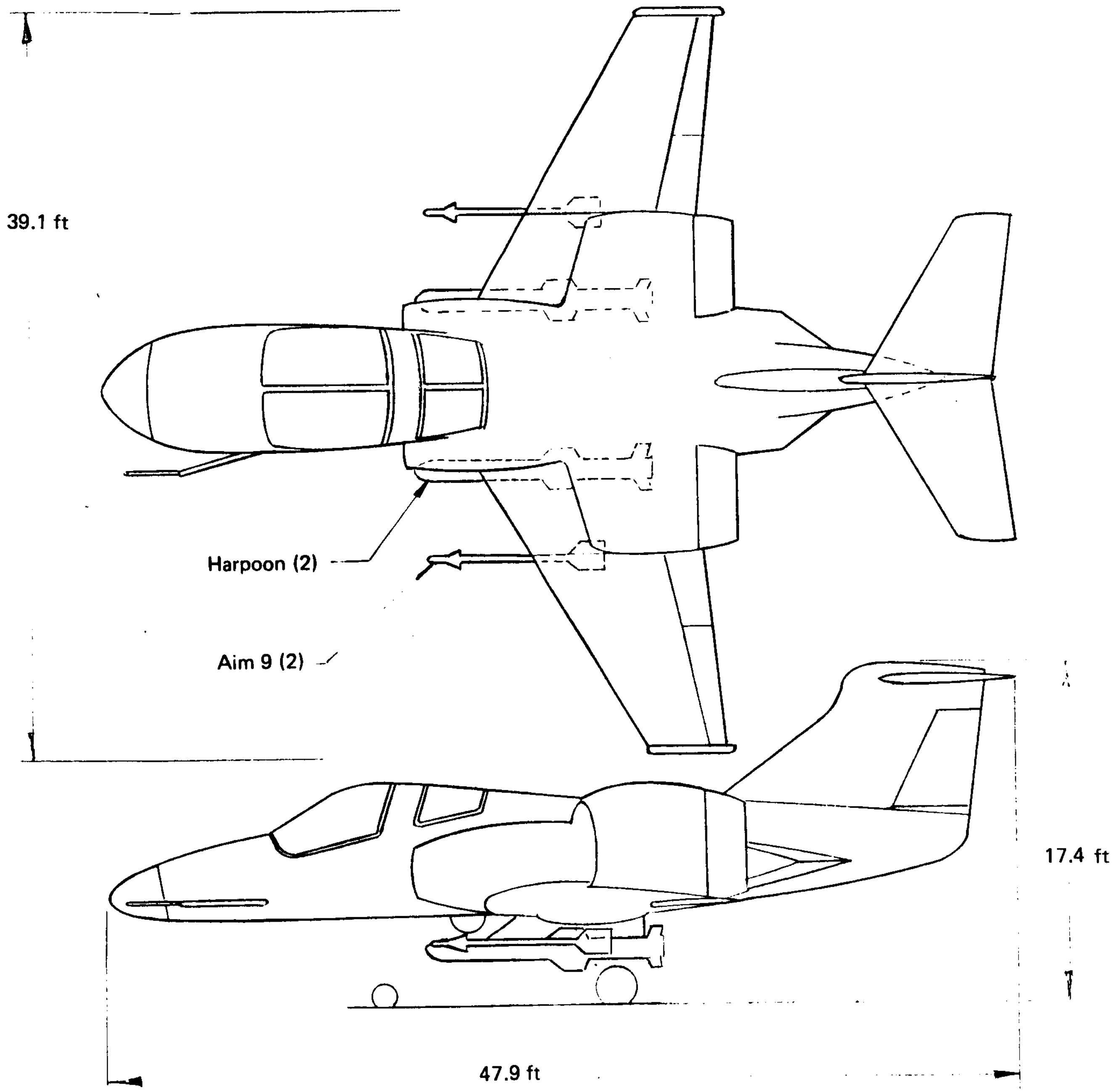


FIGURE 1-30
DIMENSIONAL AND DESIGN DATA
SA Missionized Aircraft

STOGW	(lb) (N)	34,600 (153,900)
OWE	(lb) (N)	19,546 (86,940)
BFDGW	(lb) (N)	30,380 (135,130)
Overall Length	(ft) (m)	47.90 (14.60)
Wing Span	(ft) (m)	39.10 (11.91)
Wing Span (folded)	(ft) (m)	20.60 (6.28)
Height	(ft) (m)	17.40 (5.30)
Height (for stowage)	(ft) (m)	17.40 (5.30)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	340 (31.59)	82 (7.62)	68 (6.32)
AR	4.50	3.67	.69
λ	.30	.41	.43
b (ft) (m)	39.10 (11.91)	17.40 (5.30)	6.80 (2.07)
$\Lambda c/4$ (deg)	25.0	25.0	45.0
t/c % Root/Tip	17/8	10/8	10
Airfoil	Supercritical (Modified)	64_AXXX	64_AXXX

FIGURE 1-31
GENERAL ARRANGEMENT
SURV Missionized Aircraft

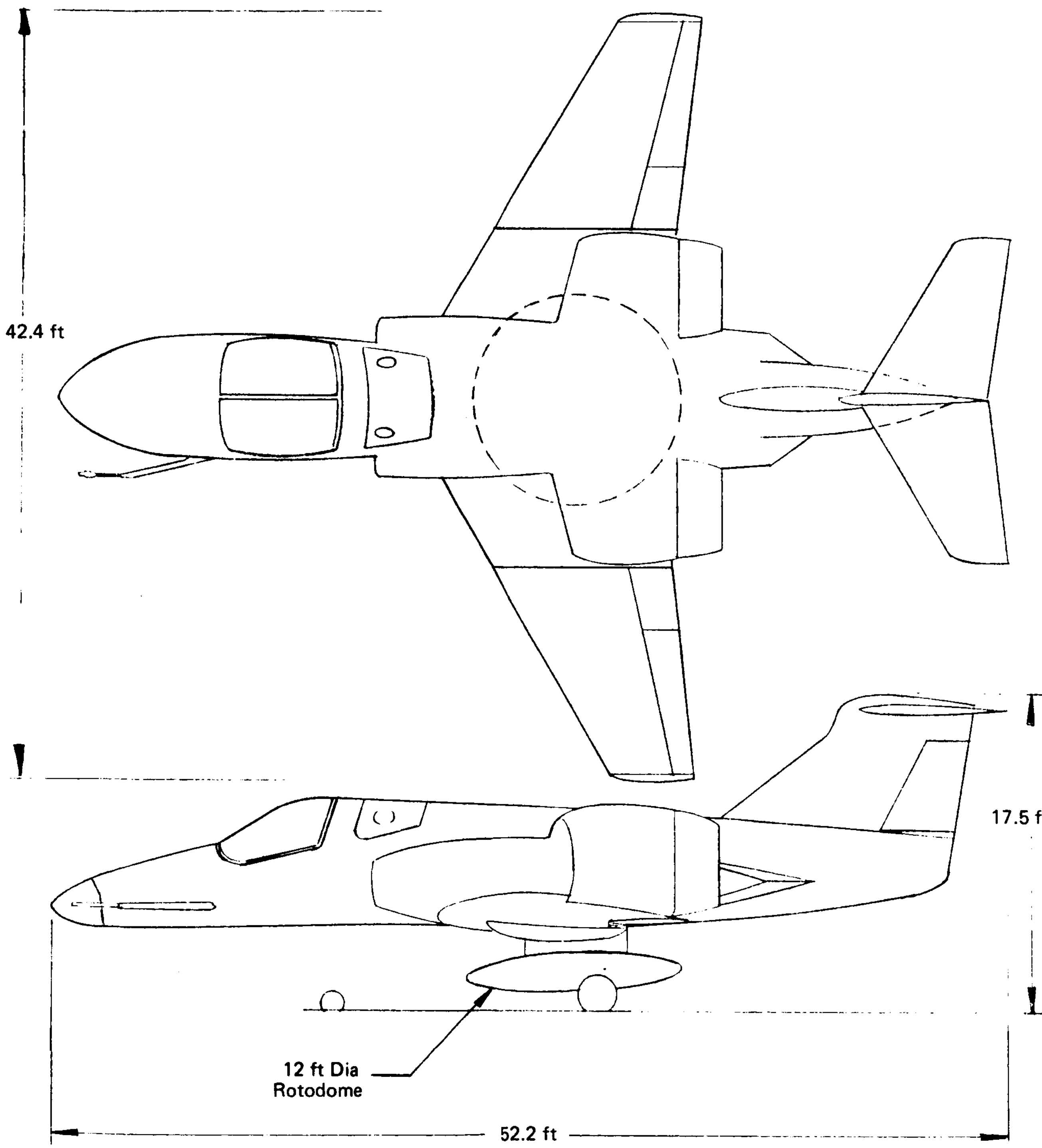


FIGURE 1-32
DIMENSIONAL AND DESIGN DATA
SURV Missionized Aircraft

STOGW	(lb) (N)	38,800 (172,580
OWE	(lb) (N)	24,777 (110,208)
BFDGW	(lb) (N)	33,160 (147,495)
Overall Length	(ft) (m)	52.20 (15.91)
Wing Span	(ft) (m)	42.40 (12.92)
Wing Span (folded)	(ft) (m)	20.80 (6.34)
Height	(ft) (m)	17.50 (5.33)
Height (for stowage)	(ft) (m)	17.50 (5.33)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	400 (37.16)	88 (8.18)	68 (6.32)
AR	4.50	3.67	.69
λ	.30	.41	.43
b (ft) (m)	42.40 (12.92)	18.00 (5.49)	6.83 (2.08)
$\Lambda c/4$ (deg)	25.0	25.0	45.0
t/c % Root/Tip	17/8	10/8	10
Airfoil	Supercritical (Modified)	64_AXXX	64_AXXX

fuselage. Adequate space is provided for all mission avionics. The third gas generator faces forward, in the center fuselage, and has its inlet on the upper fuselage surface just aft of the rear pilot compartment. It is interconnected with the basic system as described in Section 1.3. Approximately 70% of the mission fuel is carried in the inner wing and the remainder in fuselage tanks.

CSAR (Missionized) Aircraft

Figure 1-33 shows the general arrangement and locations of mission equipment and payload. Figure 1-34 presents the principal weights and geometric characteristics of the CSAR aircraft. The aircraft accommodates a crew of four and has space for the rescue of two personnel in addition to that required for avionics equipment. The mission load consists of AIM-9 (2) missiles, and a 7.62mm gun with 1000 rounds of ammunition installed on the underside of the forward fuselage. The AIM-9 missiles are carried on the outboard wing stations. All mission fuel is carried internally with an equal distribution between wing and fuselage tanks. A hatch is provided behind the rear pilot compartment for rescue of personnel, and pressurized cabin space is provided for controlled environment.

VOD (Missionized) Aircraft

Figure 1-35 shows the general arrangement of the VOD aircraft. Figure 1-36 presents the principal weights and geometric characteristics. The aircraft accommodates a crew of three and has the capability to transport internally various types of payload including 23 passengers, the F401 engine on its stand, three 463L half size pallets, or rotor blades up to 420 inches in length. The third gas generator is located beneath the floor in the rear of the center fuselage. It is interconnected with the basic system as described in Section 1.3. All mission fuel is carried internally with approximately an equal distribution between wing and fuselage tanks.

The pressurized cargo bay is 73.5 inches wide at the floor, 79 inches high at the aircraft centerline, and 268 inches long (to the loading ramp). The floor is designed to accommodate a cargo handling system utilizing three 463L half size pallets which are 54 inches wide and 88 inches long. When the loading ramp, which is 66 inches wide, is in the down position, it is inclined 15° to the loading ground line. This is accomplished by extending the nose landing gear 19 inches from the static position.

Three emergency exits are provided in addition to the main door and ramp for escape and ditching. Two 20 by 36 inch windows are located in the cargo compartment and a 24 by 24 inch overhead hatch is provided aft of the pilots' compartment. Survival gear, including life rafts, is provided for the three-man crew.

FIGURE 1-33
GENERAL ARRANGEMENT
CSAR Missionized Aircraft

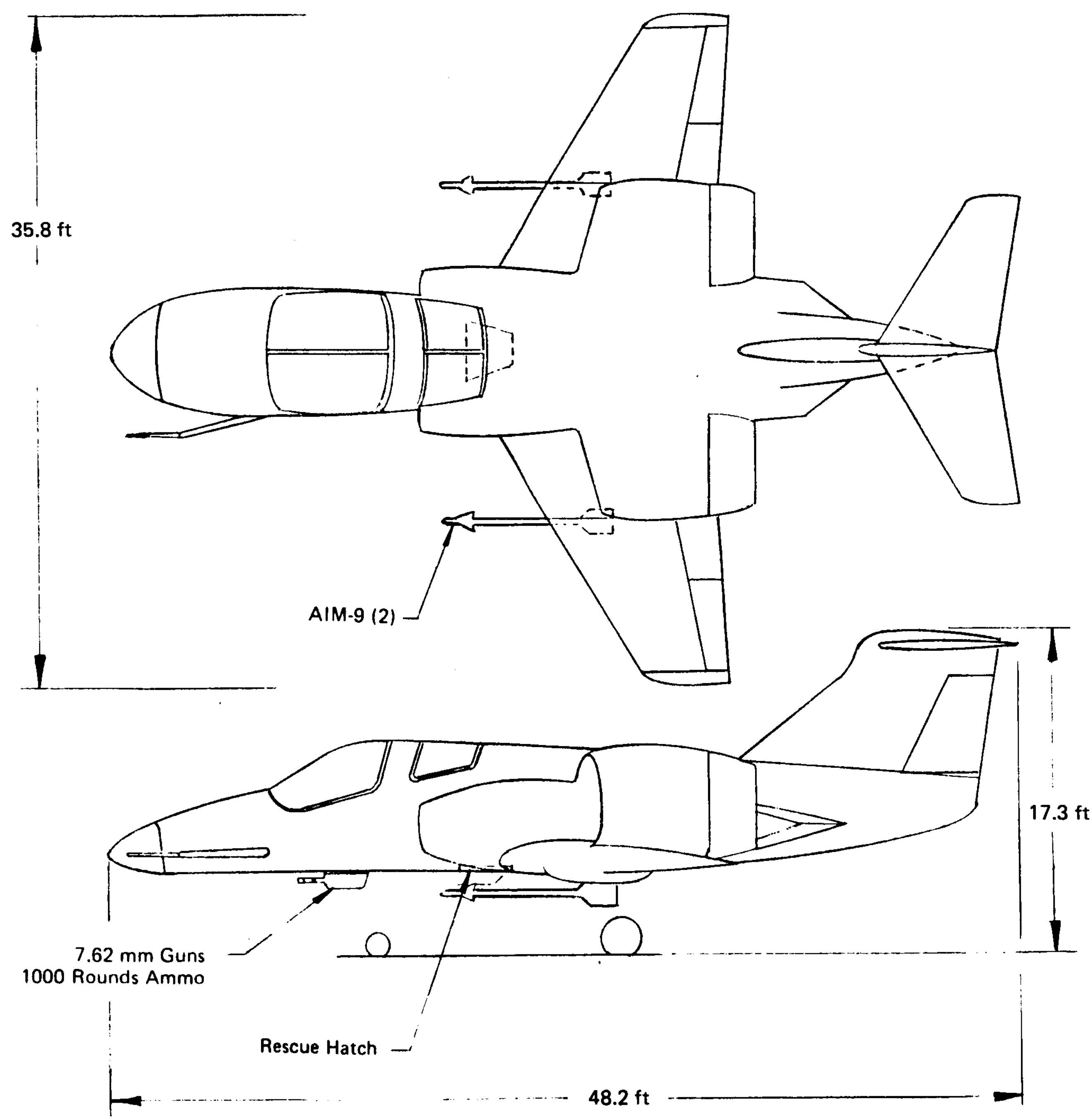


FIGURE 1-34
DIMENSIONAL AND DESIGN DATA
CSAR Missionized Aircraft

STOGW	(lb) (N)	33,300 (148,120)
OWE	(lb) (N)	21,248 (94,511)
BFDGW	(lb) (N)	28,740 (127,835)
Overall Length	(ft) (m)	48.20 (14.69)
Wing Span	(ft) (m)	35.80 (10.91)
Wing Span (folded)	(ft) (m)	20.30 (6.18)
Height	(ft) (m)	17.30 (5.27)
Height (for stowage)	(ft) (m)	17.30 (5.27)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	320 (29.73)	75 (6.97)	68 (6.32)
AR	4.00	3.67	.69
λ	.30	.40	.43
b (ft) (m)	35.8 (10.91)	16.60 (5.06)	6.83 (2.08)
$\Lambda c/4$	25.0	25.0	45.0
t/c % Root/Tip	18/7	10/8	10
Airfoil	Supercritical (Modified)	64_AXXX	64_AXXX

FIGURE 1-35
GENERAL ARRANGEMENT
VOD Missionized Aircraft

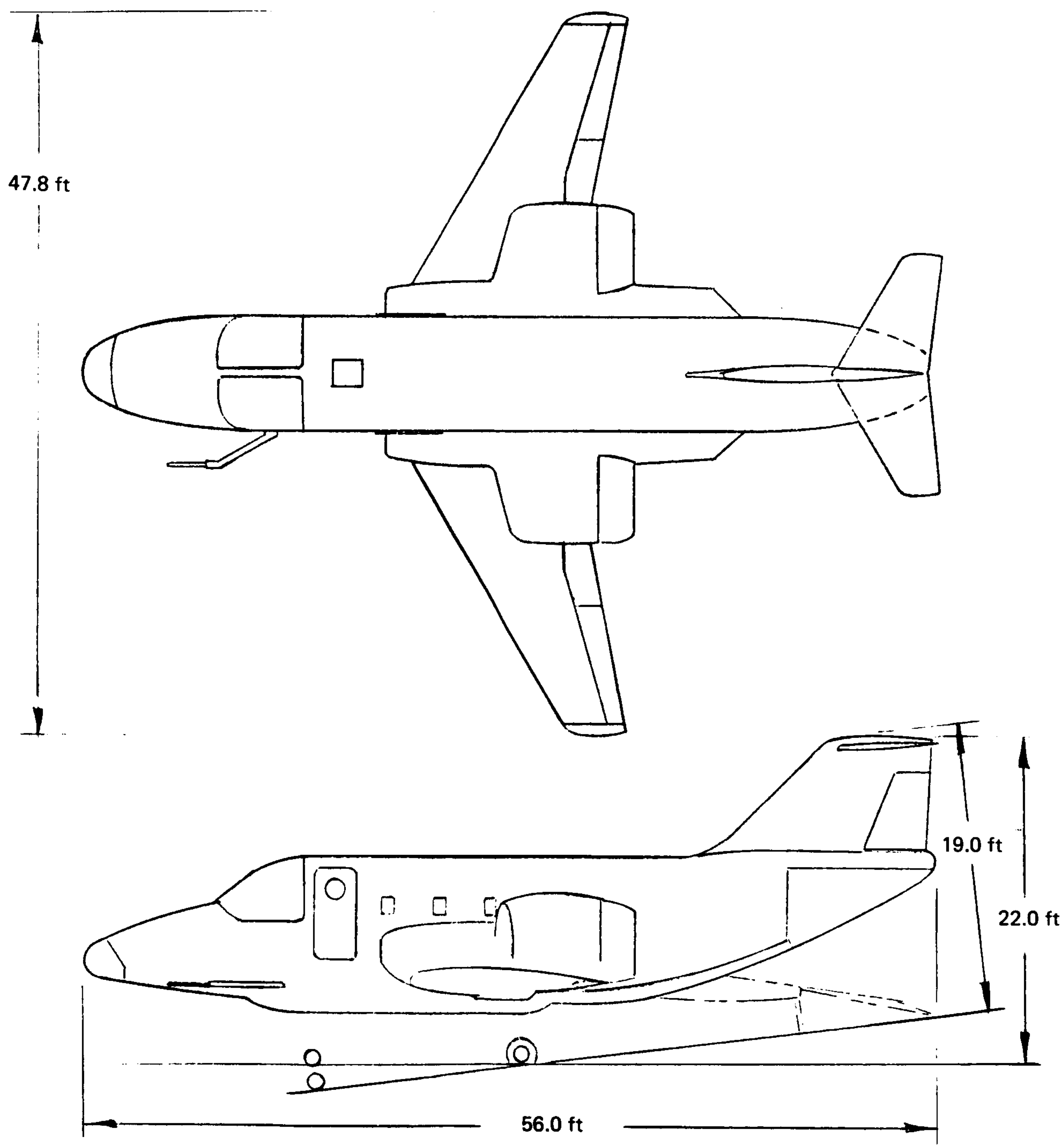


FIGURE 1-36
DIMENSIONAL AND DESIGN DATA
VOD Missionized Aircraft

STOGW	(lb) (N)	44,800 (199,270)
OWE	(lb) (N)	21,756 (96,770)
BFDGW	(lb) (N)	37,400 (166,355)
Overall Length	(ft) (m)	56.00 (17.07)
Wing Span	(ft) (m)	47.80 (14.57)
Wing Span (folded)	(ft) (m)	28.40 (8.65)
Height	(ft) (m)	22.00 (6.71)
Height (for stowage)	(ft)	19.00 (5.79)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	400.00 (37.16)	70.00 (6.50)	77.40 (7.19)
AR	5.70	3.67	.76
λ	.30	.40	.48
b (ft) (m)	47.80 (14.57)	16.00 (4.88)	7.70 (2.34)
$\Lambda c/4$ (deg)	25.0	25.0	37.8
t/c % Root/Tip	18/8	10/8	10
Airfoil	Supercritical (Modified)	64_AXXX	64_AXXX

1.6 WEIGHTS AND DESIGN CRITERIA

The configurations presented in the Group Weight Statements are the results of studies used to develop vehicles capable of performing the guideline missions. Design criteria and parameters varied for each configuration. A summary of design criteria is provided in Figure 1-37. Since these aircraft are evaluated as 1985 production vehicles, structural weights were reduced assuming the use of advanced materials and fabrication techniques, as well as investigating the use of advanced state-of-the-art subsystem components.

Group weight statements for the five point design aircraft are presented in Figure 1-38. Figure 1-39 is an illustration of composite structural material (graphite epoxy) used in one of the point design configurations, the CSAR aircraft. As in all the point design aircraft, the structural weight saved is approximately 14%.

Weight prediction methods and derived group weights for similar type V/STOL aircraft (Model 260-318) were presented to NAVAIR in November 1974 for information and evaluation.

FIGURE 1-37
MISSIONIZED AIRCRAFT DESIGN CRITERIA SUMMARY

	ASW	SA	SURV	CSAR	VOD
Maximum Takeoff Gross Weight (lb) (N)	42,900 (190,820)	34,600 (153,900)	38,800 (172,580)	33,300 (148,120)	44,800 (199,270)
Basic Flight Design Gross Weight (lb) (N)	37,220 (165,554)	30,380 (135,130)	33,160 (147,495)	28,740 (127,835)	37,400 (166,355)
VTOGW (lb) (N)	31,850 (141,668)	27,000 (120,096)	34,500 (153,456)	27,000 (120,096)	34,500 (153,456)
Ultimate Design Load Factor (g) (m/sec^2)	4.50 (1.37)	4.50 (1.37)	4.50 (1.37)	7.50 (2.28)	4.50 (1.37)
Maximum Dynamic Pressure (psf) (N/m^2)	535 (25,630)	535 (25,630)	535 (25,630)	949 (45,460)	535 (25,630)
Ult. Differential Cabin Pressure (psi) (N/m^2)	9.4 (64,860)	9.4 (64,860)	9.4 (64,860)	9.4 (64,860)	9.4 (64,860)
Wing Area/Aspect Ratio (ft^2)/ (m^2)/	500/5.0 (46.45)/	340/4.5 (31.59)/	400/4.5 (37.16)/	320/4.0 (29.73)/	400/5.7 (37.16)/
Gas Generator (No./W_a) (lb/sec) (Kg/sec)	2/86 2/(39.01)	2/75 2/(34.02)	3/70 3/(31.75)	2/80 2/(36.29)	3/70 3/(31.75)
Fan Diameter (in.) (m)	61 (1.55)	57 (1.45)	59 (1.50)	59 (1.50)	59 (1.50)
No. Crew	4	3	4	4	3
Payload	2 MK-46 50 Sonobuoys	2 Harpoon 2 AIM-9	Electronics w/12' Rotodome	2 Evacuees 2 AIM-9	5000 lb
Maximum Internal Fuel (lb) (N)	14,200 (63,161)	10,530 (46,837)	14,000 (62,272)	11,400 (50,707)	18,000 (80,064)

FIGURE 1-38
MISSIONIZED AIRCRAFT GROUP WEIGHT STATEMENTS

Item	VOD	ASW	SA	SURV	CSAR
Wing	1885	1960	1331	1455	1460
Vertical Tail	170	175	170	170	170
Horizontal Tail	172	232	166	211	217
Fuselage	4833	3278	3071	3262	3932
Nose Landing Gear	270	269	260	260	260
Main Landing Gear	633	631	600	600	600
Surface Controls	758	790	685	685	685
Engine Section	202	184	184	202	184
Propulsion					
Gas Generators	2217	1650	1518	2217	1578
Air Induction	155	125	125	155	125
Water Injection Sys.	---	120	120	---	120
Fuel System	650	500	500	525	500
Controls	60	40	40	60	40
Lift Fan	700	740	680	700	700
Lift Fan Louvers	200	207	195	200	200
Lift/Cruise Fans	1400	1480	1360	1400	1400
L/C Fan Deflectors	1300	1345	1270	1300	1300
Ducting	900	634	568	680	594
Valves	551	444	416	551	434
Start/AMAD	350	350	350	350	350
Instruments	234	234	234	234	234
Hydraulics	382	382	335	335	335
Electrical	462	462	462	462	462
Electronics	650	3080	1580	6237	783
Armament	---	313	313	---	740
Furnishings	365	734	560	734	969
Air Conditioning	500	435	435	435	435
Anti-Ice	150	150	150	150	150
Auxiliary Gear	7	7	7	7	7
Weight Empty	20,156	20,951	17,685	23,577	18,964
Crew	540	720	540	720	720
Trapped Fuel	160	110	105	110	110
Oil	90	90	90	90	90
O_2 and Miscellaneous	210	280	210	280	280
Mtg. Hdw. - Ext. Stores	600*	310	536	---	306
Gun and Ammo	---	---	---	---	398
H_2O	---	380	380	---	380
Operating Weight Empty	21,756	22,841	19,546	24,777	21,248
Fuel	18,044	17,207	12,332	14,023	11,262
Payload	5000	2852	2722	---	790
Takeoff Gross Weight (STO)	44,800	42,900	34,600	38,800	33,300

*463L Roller Conveyor System

FIGURE 1-39
TYPICAL COMPOSITE WEIGHT SAVINGS
CSAR Aircraft

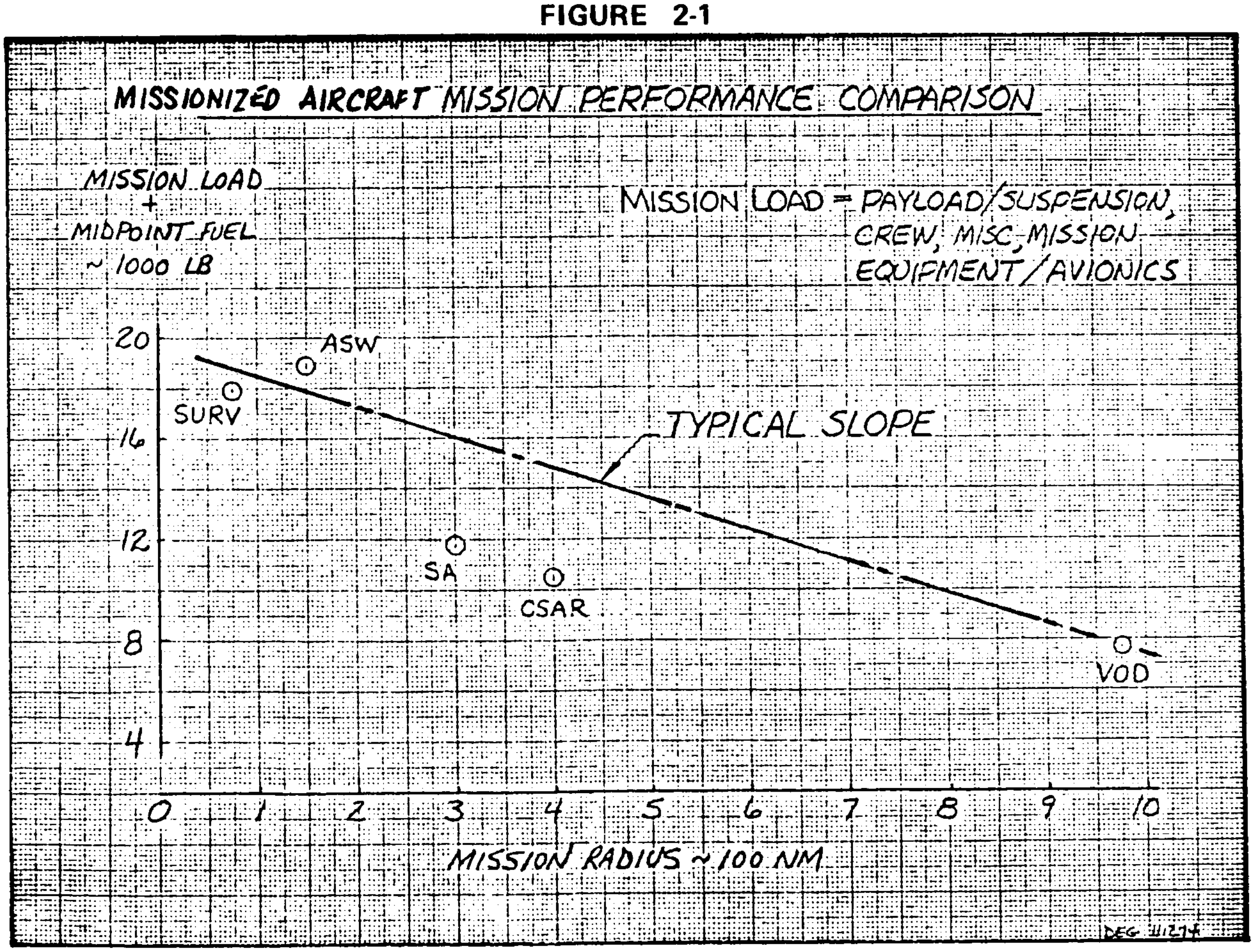
Item	Structural Weight All-Metal Design	Structural Weight Composite Design	Weight Saved	% Saved	Weight Composite Used	Lb Saved per Lb Composite Used
Wing	1855	1460	395	21.3	465	.849
Horizontal Tail	293	217	76	25.9	94	.809
Vertical Tail	236	170	66	28.0	93	.710
Fuselage	4423	3932	491	11.1	614	.800
Nose Landing Gear	292	260	32	11.0	52	.615
Main Landing Gear	654	600	54	8.3	86	.628
Air Induction	177	125	52	29.3	64	.812
Engine Section	184	184	0	0	0	0
Totals	8114	6948	1166	14.3	1468	.794

2. COMPROMISE MISSION AND COMMONALITY APPROACH

2.1 COMPROMISE MISSION

A review of the five mission profile definitions shows that many commonalities exist, the major difference being the midpoint fuel allocation(s) which may be considered to be the equivalent of an outbound payload requirement. A mission load concept for defining an aircraft suitable for multipurpose use has been developed from previous advanced design aircraft studies. Mission load has been defined as the sum of the payload plus support, special mission equipments such as avionics or cargo loading and tie-down provisions, and crew members plus parachutes, trapped fuel and oil, and miscellaneous items. Mission load in the commonality aircraft study is expanded to include the midpoint fuel required for loiter, hover, dash, and combat as required. Figure 2-1 presents the redefined mission loads for the five point design aircraft plotted against their respective design radius to fulfill the study requirements. The VOD aircraft range requirement is converted to an equivalent radius requirement. Superimposed is a line through the VOD point with a load-radius slope typical of a lift/cruise fan V/STOL aircraft (30,000 lb VTOGW class) operating at a STO gross weight defined by a 400 ft deck roll with 10 kt WOD. This line is a good representation of the ASW, SURV, and VOD data points. The SA and CSAR data points fall below the line indicating that the design requirements for these missions are less critical than the ASW, SURV, and VOD mission requirements and that the desired capability for the SA and CSAR aircraft can be a fallout of the other requirements.

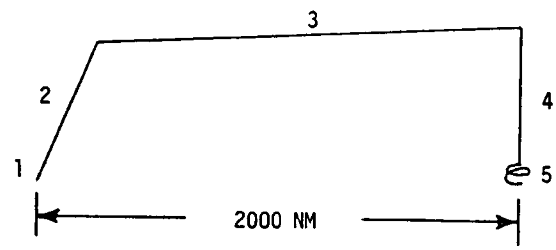
FIGURE 2-1



The VOD mission is selected as the pertinent design requirement since the extended radius or range requisite dictates cruise efficiencies typical of fixed wing aircraft. If the VOD point on Figure 2-1 is ignored, another line of roughly double the slope of the one shown could be drawn to encompass the remaining four points. The aircraft represented by this revised line would exhibit half the cruise efficiency of a fixed wing aircraft and probably much reduced speed and altitude characteristics. Multiple inflight refueling would then be required to accomplish the long range VOD mission. Performance of such aircraft would seriously reduce the surveillance and attack capabilities potentially available to the Military within the current state of the art.

Figure 2-2 defines the recommended compromise mission profile, on a range basis as requested at the NASA/Navy mid-study briefing review. The loadings, range, and takeoff conditions are as specified by the VOD aircraft study requirements while the profile segments are consistent with the commonalities of the five design missions. The missionized aircraft (VOD configuration) mission performance using the compromise mission profile is presented in Figure 2-3 for STO gross weights of 45,800 lb corresponding to the 450 ft deck roll, 20 kt WOD criterion and 44,300 lb, which satisfies the payload-range requirement. Also presented for comparison purposes is mission performance for the smaller fuselage ASW configuration at a STOGW of 40,400 lb corresponding to the 450 deck roll, 20 kt WOD criterion. The mission breakdown estimate shown in Figure 2-4 is for the 44,300 lb takeoff gross weight which satisfies the VOD mission requirement.

FIGURE 2-2
RECOMMENDED COMPROMISE MISSION



STO: SL 89.8°F DAY — 450 FT DECK RUN, 20 KT WOD

LOADING — 5000 LB
RANGE — 2000 NM

1) WARMUP, TO, ACCEL TO V_c	2 MIN INTERMEDIATE THRUST, SL 1/2 MIN TAKEOFF THRUST, SL
2) CLIMB TO BCAV	INTERMEDIATE THRUST
3) CRUISE OUT BCAV	2000 NM LESS CLIMB DISTANCE
4) DESCEND TO SL	NO FUEL USED, NO TIME/DIST CREDIT
5) LANDING AND RESERVE	10 MIN BEST ENDURANCE SPEED, SL 5 PERCENT TOTAL INITIAL FUEL

Notes: 5 PERCENT FUEL FLOW TOLERANCE
MISSION PROFILE - ICAO STANDARD DAY

FIGURE 2-3

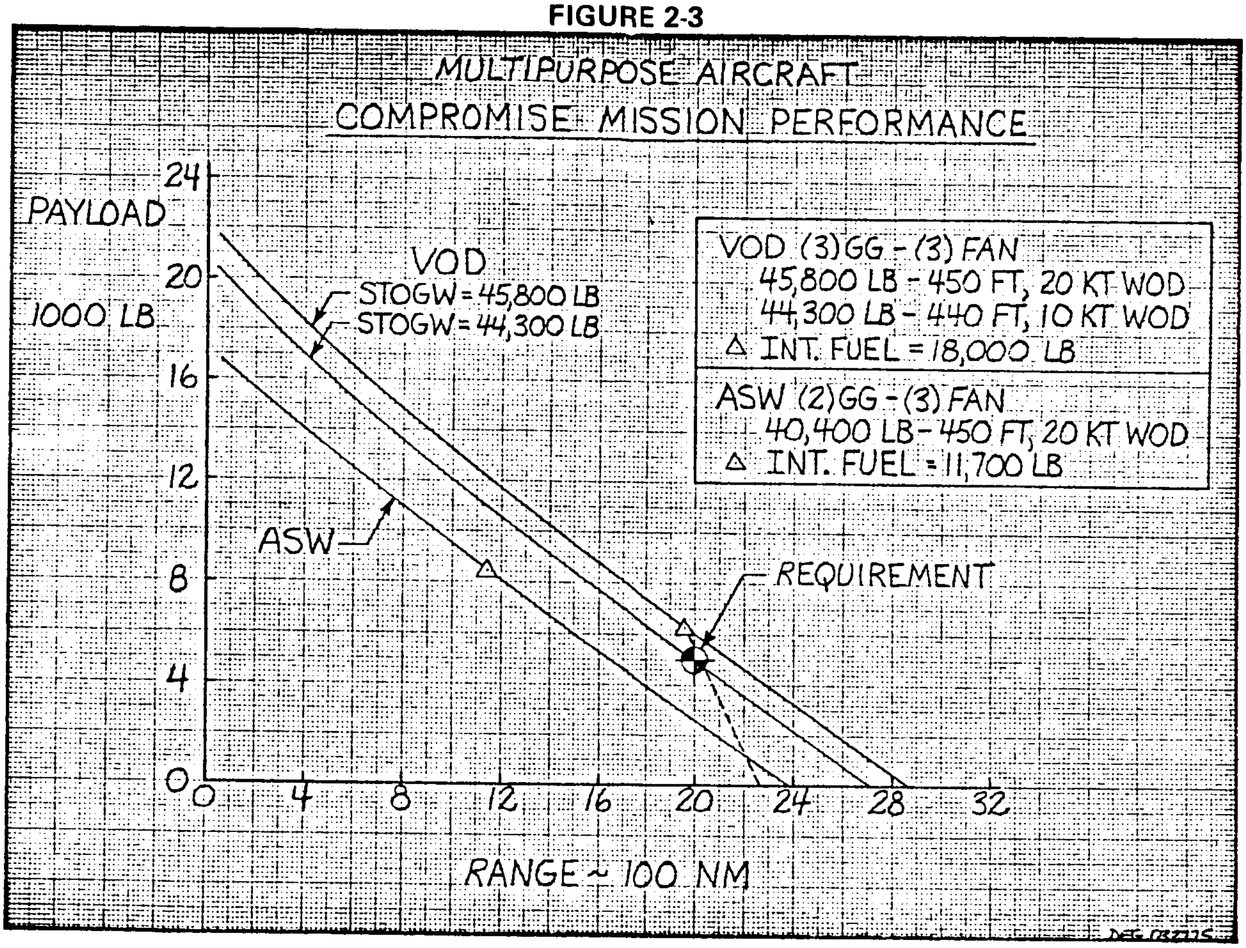


FIGURE 2-4
COMPROMISE MISSION BREAKDOWN
VOD Multipurpose Aircraft

Mission Component \ Breakdown	G.W. (lb)	Alt. (ft)	Mach	Fuel (lb)	Dist. (nm)	Time (hr)
	44,300					
1. Warmup, TO, Accel. to V_c 2 min. Intermediate + 1/2 min. TO				645	---	0.042
	43,655	SL				
2. Climb to BCAV at Intermediate Thrust			0.60	1370	82	0.227
	42,285	33,800				
3. Cruise BCAV			0.72	14,409	1918	4.640
	27,876	36,089				
4. Descend to SL, No Credit				---	---	---
	27,876	SL				
5. Landing Allowance and Reserves: 10 min. Loiter, Best Endurance 5% Total Initial Fuel			0.28	475 890	---	0.167
	26,511					
Total				17,789	2000	5.08

Note: 5 percent fuel flow tolerance included

If the VOD aircraft were utilized for all missions, the fuselage weight and drag penalties ($\Delta W \approx 1765$ lb, $\Delta f \approx 2.5$ ft^2) would reduce the other mission capabilities, thereby detracting somewhat from the selection of the VOD as the compromise mission. However, aircraft technology, independent of concept, is capable of offering a level of commonality that permits a fuselage size change if cargo volume requirements vary by large amounts.

2.2 COMMONALITY APPROACH

The commonality approach for the multipurpose aircraft was based on the premise of performing all missions with a minimum number of changes to airframe and systems. Major considerations were fuselage size and use of high value components, i.e. propulsion system, control system, wing, empennage, etc. Use of a common fuselage for all missions would result in limitations on cargo applications, penalties in weight, drag, and size, which reduces the mission performance and aggravates the engine out landing requirement. Plug additions to a basic fuselage were also considered and dropped due to the problems associated with changes in lift/cruise fan and engine location and mounting, landing gear locations, power transmission system, and other major impacts.

A two fuselage size approach, using common high value components, was selected as the best solution - a small fuselage for ASW, SA, CSAR, and SURV, and a large fuselage for VOD. The recommended commonality approach, Figure 2-5, was to use the two different fuselage sizes with two growth (80 lb/sec) J97 gas generators. This would result in short landings of less than 100 ft with 20 kt WOD rather than vertical landing for the SURV and VOD when a gas generator was inoperative. An alternate approach, in the event engine out "V" landing was a firm requirement, was to use three growth (80 lb/sec) J97 gas generators in the SURV and VOD thereby retaining gas generator commonality.

The final NASA/Navy approved approach, Figure 2-6, was to use the small fuselage size with two growth J97 gas generators for ASW, SA, CSAR, and SURV and accept short landing on the SURV. The VOD would use the large fuselage with three existing J97 gas generators so that the engine out vertical landing requirement could be met with passengers on board. This approach was selected for study purposes in order to explore two fan/engine combinations in the cruise mode.

FIGURE 2-5
RECOMMENDED COMMONALITY APPROACH

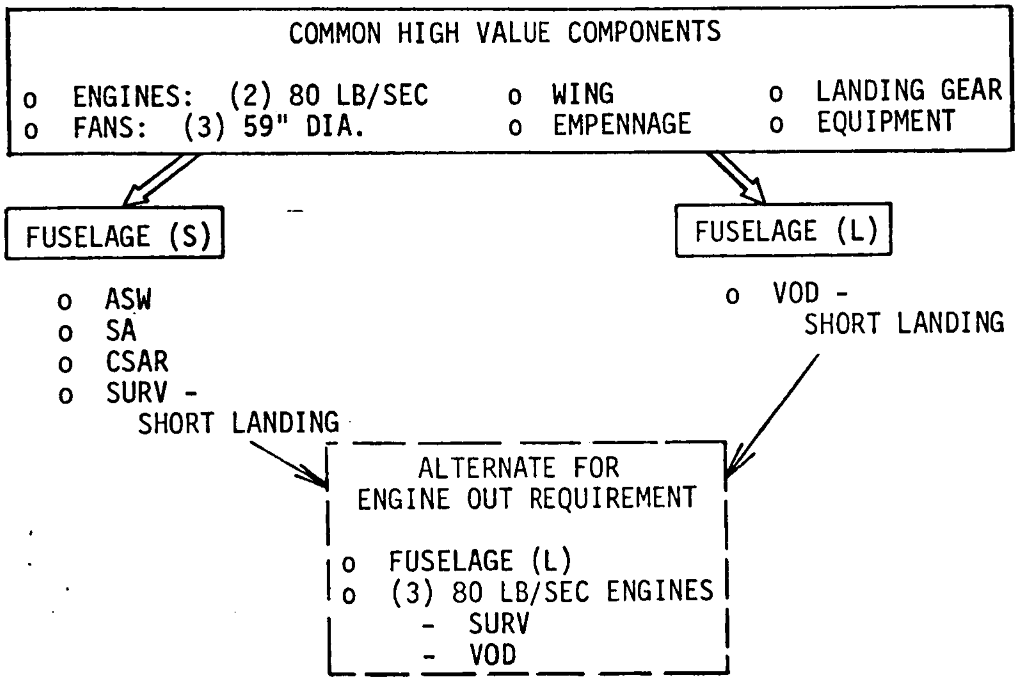
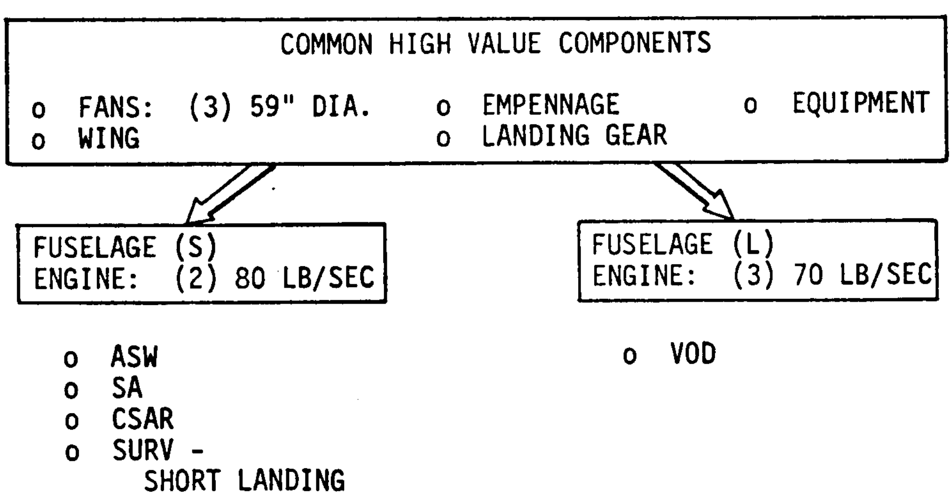


FIGURE 2-6
APPROVED COMMONALITY APPROACH



3. MULTIPURPOSE AIRCRAFT

3.1 SUMMARY

Based on the commonality approach discussed in Section 2.2, elements of each missionized aircraft were reviewed to determine reasonable areas of compromise for the ASW, SA, CSAR, and SURV configurations and missions. The design compromises selected were minimal and consisted of:

(1) Common design load factor of 3 g.

(2) Common design "q" of 535 psf (0.60 M at S.L.).

(3) Common surface search radar.

The compromise in load factor from 5 g to 3 g and the reduction in speed from 0.80 M to 0.60 M at S.L. affects only the CSAR mission and results in a weight saving of approximately 920 lb. All avionic suites are identical to those of the missionized aircraft except for the use of a common surface search radar in the ASW. Use of this radar achieves commonality in nose moldline and improved visibility while still having the capability to detect surface vessels in moderate sea states out to 120 nautical miles.

The common usage of high value components included gas generators, fans, wing/nacelle assembly, empennage, nose assembly, and landing gears. The flight control system, hydraulics, fuel system, starting and auxiliary drive (AMAD), instruments, and avionics as well as many other subsystems/components were also adaptable to all versions.

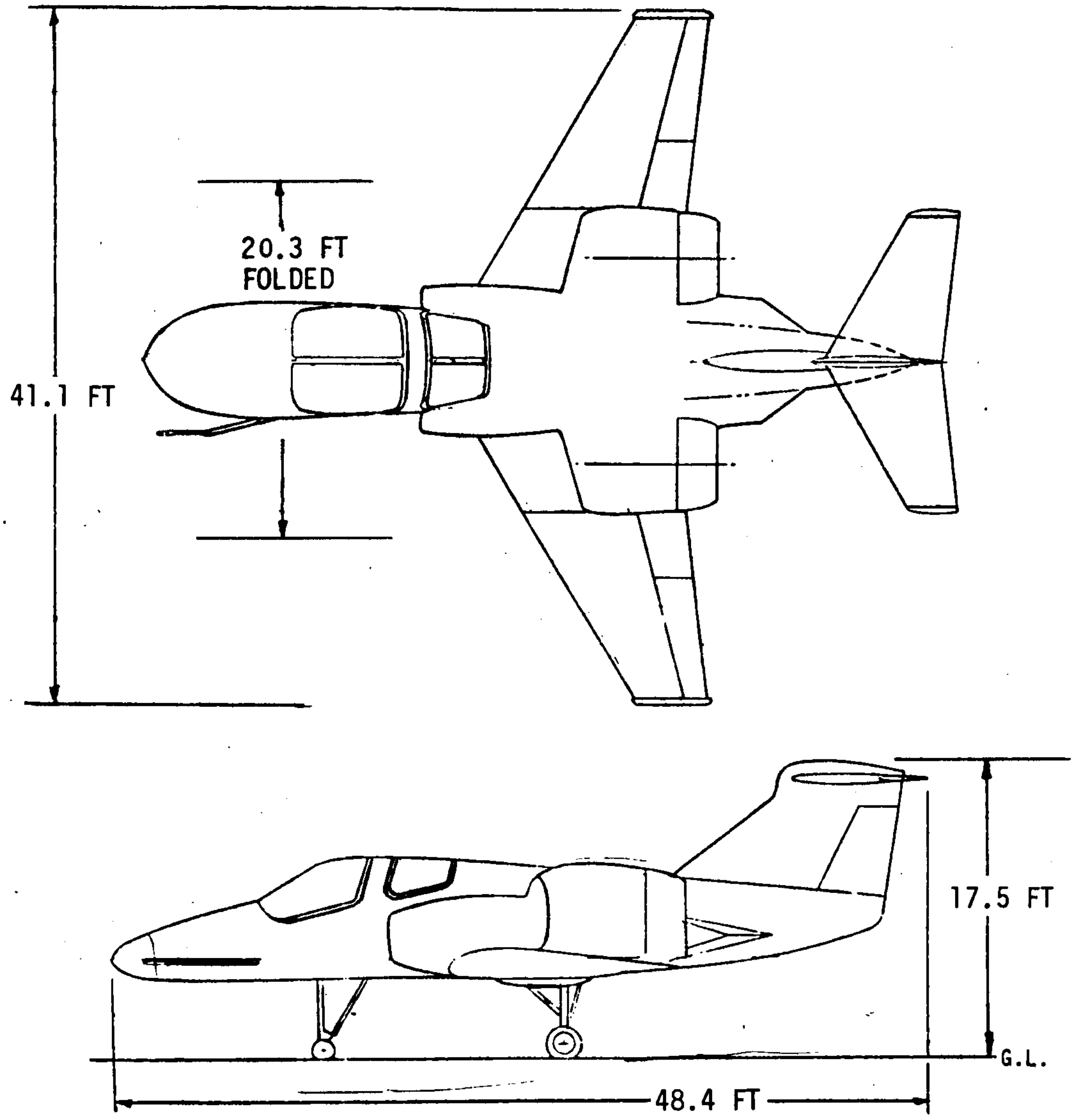
Multipurpose Aircraft

The general arrangement of the smaller fuselage multipurpose aircraft is shown in Figure 3-1, and that of the larger fuselage (VOD) in Figure 3-2. The common wing selected has an area of 368 ft^2 and aspect ratio of 4.5 when applied to the smaller fuselage, and 432 ft^2 with an aspect ratio of 4.7 when used with the larger fuselage. Since it was directed that the ASW mission was the highest priority among the five Navy missions considered, the common items favor the ASW requirement. Three wet stations are provided even though some missions can be performed with internal fuel only. The versatility of the multipurpose aircraft in the carriage of external stores is discussed in Section 3.6. The pilot's vision capability in the multipurpose aircraft is superior to that of the AV-8A Harrier both forward and over the side, which is important for vertical spot landing aboard ship. The aircraft spotting factor of the smaller multipurpose fuselage as related to the A-7(s) was determined to be 0.98 in accordance with the ground rules and 0.92 when fuselage/empennage overlap was used. Characteristics of the various versions of the two multipurpose aircraft are summarized in Figure 3-3. All TOGW's are based on zero sink off the bow.

Mission Capability

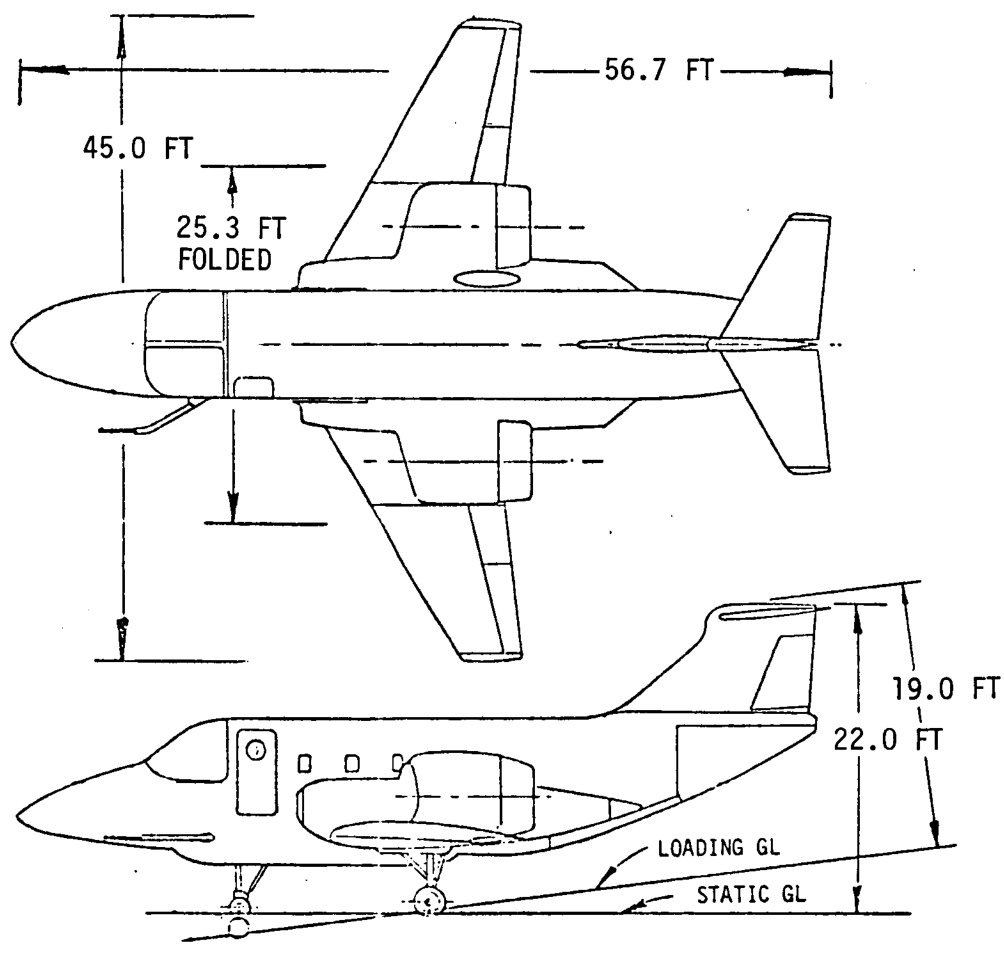
The multipurpose aircraft performance was assessed against the original missions established for the missionized aircraft as required by the Statement of Work. It was determined that the multipurpose aircraft could meet or exceed the requirements for all missions except for a moderate reduction in Time-on-Station (TOS) for the ASW when the mission was performed precisely to all ground rules.

FIGURE 3-1
MULTIPURPOSE AIRCRAFT
ASW, SA, SURV, CSAR



STOGW - 38,700 lb
Weight Empty - 19,475 lb (ASW)
Gas Generators - (2) J97 (Growth)
Fans - (3) 59 in. dia
Wing Area - 368 sq ft
Internal Fuel - 11,700 lb

FIGURE 3-2
MULTIPURPOSE VOD AIRCRAFT



STOGW - 45,000 lb
Weight Empty - 19,846 lb
Gas Generators - (3) J97-GE-100
Fans - (3) 59 in.dia
Wing Area - 432 sq ft
Internal Fuel - 18,000 lb

FIGURE 3-3
CHARACTERISTICS SUMMARY MULTIPURPOSE AIRCRAFT

	ASW	SA	SURV	CSAR	VOD
STOGW (lb)	38,700	33,900	38,000	31,300	45,000
OWE (lb)	21,250	19,577	24,117	20,465	21,511
Landing Wt.(Engine Out) (lb)	22,250	20,577	25,117**	21,865*	27,511*
Mission Fuel (lb)	14,598	11,700	13,883	10,955	18,489
Wing Area (ft^2)	368	368	368	368	432
Aspect Ratio	4.5	4.5	4.5	4.5	4.7
Gas Generators	2	2	2	2	3
Airflow (lb/sec)	80	80	80	80	70
Fan Diameter (in.)	59	59	59	59	59
Design Fan Pressure Ratio	1.32	1.32	1.32	1.32	1.32
M_{Cruise} (Opt. Altitude)	0.74	0.74	0.74	0.74	0.73

* Includes Passengers/Evacuees Plus 1000 lb Fuel
** Rolling Vertical Landing (RVL): 100 Ft Deck Roll, 10 KT WOD

The ASW requirements were exceeded when the aircraft used a 20 kt WOD and loitered at 30,000 ft. The ASW requirements were also met when the aircraft used 2 ft sink off-the-bow, as in Harrier calculations, and loitered at 30,000 ft; or, loitered on one gas generator at 10,000 ft. The aircraft can perform the SA mission with an excess of 1.4 hour TOS; the SURV mission with an excess of 0.3 hour TOS; the CSAR mission with an excess of both 1.6 hour TOS and 10 min hover; and, the VOD mission using 50 ft less deck roll than allowed. The multipurpose aircraft was found to be well suited for the Navy missions.

3.2 MISSION PERFORMANCE

The following paragraphs provide a performance summary for the multipurpose aircraft showing the Navy mission requirement, the multipurpose aircraft capability for the specific Navy mission, and alternate capabilities.

Anti Submarine Warfare (ASW)

Figure 3-4 presents an ASW point design window for the selected aspect ratio of 4.5 developed as described in Section 1. Design window data were also generated for wing aspect ratios of 5.0 and 5.5. Two loiter TOS periods, 4 and 3 hours, were investigated. No windows were found for the 4-hour TOS due to the previously discussed design compromises. A 3-hour TOS, point design window for an aspect ratio of 4.5 is defined by the transition, emergency VL, and minimum weight boundaries. The multipurpose aircraft with a 368 sq ft wing area, 4.5 aspect ratio, falls within the window boundaries with its location favoring transition and STO performance. Figure 3-5 shows the ASW mission performance (TOS vs Radius) for the multipurpose aircraft with an aspect ratio of 4.5 and wing area of 368 sq ft. TOS at 150 nm radius and 10,000 ft loiter altitude is 3.2 hours. The 4-hour TOS can be achieved by loiter with one gas generator at 10,000 ft; increasing the STO distance to 415 ft 20 kt WOD and loitering at 30,000 ft or using 2 ft sink off the bow and loitering at 30,000 ft. These data are summarized on Figure 3-6. Figure 3-7 provides a mission breakdown at a STOGW of 38,700 lbs. Figure 3-8 graphically shows the effect of increased loiter altitude which extends radar effectiveness and as well as both one and two gas generator operational time for the wingborne loiter segment. Figure 3-9 shows the change in loiter time with takeoff distance and WOD for a 10,000 ft loiter altitude. Use of 2 ft sink off the bow increases the loiter capability by approximately 0.25 hours.

Surface Attack (SA)

Figure 3-10 presents the SA mission performance of TOS at 20,000 ft versus radius carrying two Harpoons and two AIM-9 missiles. Excess capability relative to the 400 ft 10 kt WOD takeoff requirement is provided at a STOGW of 38,700 lb. External fuel of approximately 4400 lb is included at this takeoff weight. The 2-hour loiter at 20,000 ft and 300 nm radius requirement is satisfied at a STOGW of 33,990 lb corresponding to less than 200 ft deck roll with 10 kt WOD and full internal fuel. Figure 3-11 tabulates mission capabilities. Figure 3-12 gives the mission breakdown at the gross weight (33,990 lb, internal fuel) to meet the Navy mission requirement. Total mission time is 3.8 hours.

Surveillance (SURV)

Figure 3-13 presents the surveillance mission performance of TOS at optimum altitude versus radius with avionics system including a 12 ft dia. below fuselage rotodome. The 4-hour TOS requirement at 75 nm radius is exceeded at a STOGW of 38,700 lb (400 ft deck roll, 10 kt WOD). All mission requirements are fulfilled at a STOGW of 38,000 lb. Figure 3-14 tabulates mission capabilities. Figure 3-15 gives the mission breakdown at a gross weight of 38,000 lb. All mission fuel is internal. At 38,700 lb STOGW, a 3-hour loiter is possible at 300 nm which provides 450-plus nm radius surveillance capability considering the 12 ft rotodome detection distance. This extended radius performance is advantageous through added warning time and elimination of the aircraft as a homing beacon locator of the ship base or convoy.

FIGURE 3-4

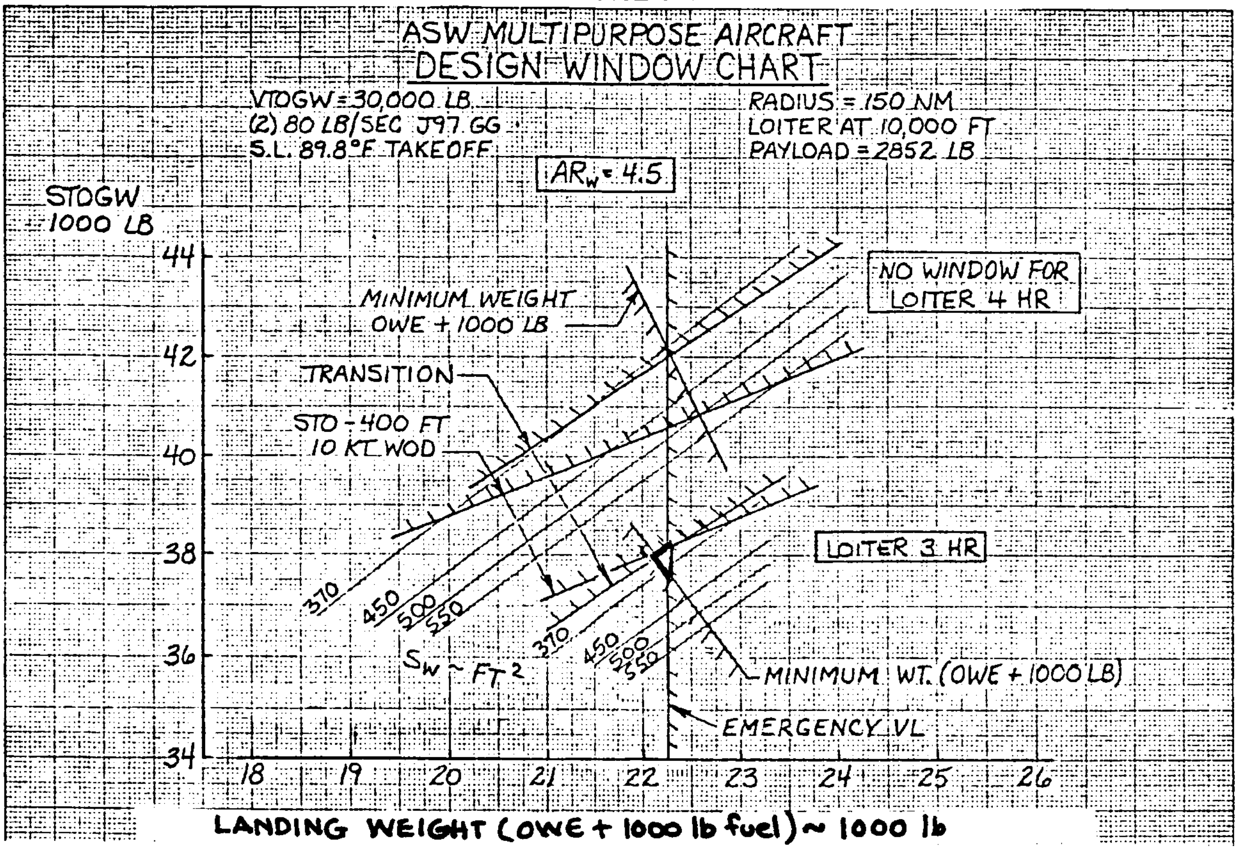


FIGURE 3-5

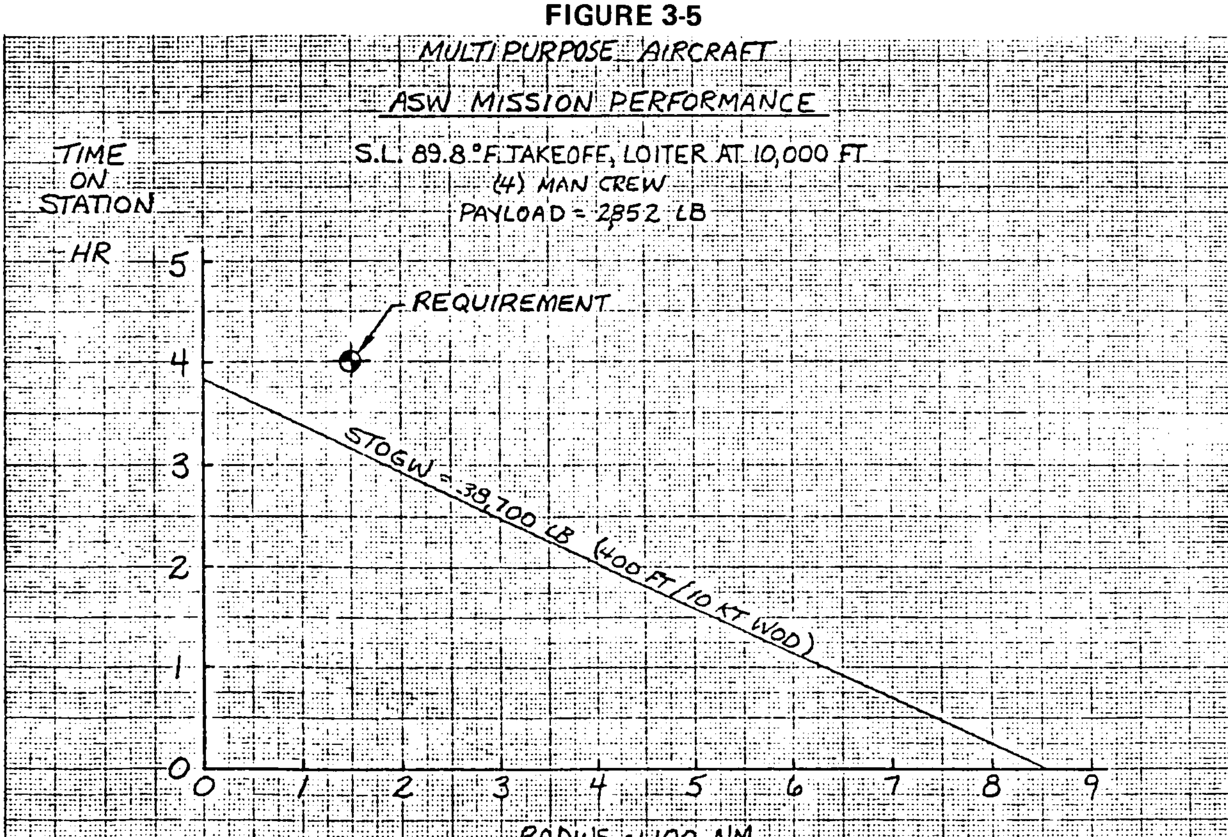


FIGURE 3-6
ASW MISSION CAPABILITY
MULTIPURPOSE AIRCRAFT

Performance		Requirement	Navy Mission	Alternate Capability					
STOGW	(lb)	---	38,700	38,700	38,700	40,000	39,700 (2)	40,000
Deck Roll	(ft)	400	400	400	400	400	400	415
WOD	(kt)	10	10	10	10	22	10	20
Payload	(lb)	2852	2852	2852	2852	2852	2852	2852
Radius	(nm)	150	150	150	150	150	150	150
Loiter TOS	(hr)	4	3.2	3.7	4.0 (1)	4.0	3.95	4.0
Altitude	(ft)	10,000	10,000	30,000	10,000	30,000	30,000	30,000
Engine Out Landing		VL	VL	VL	VL	VL	VL	VL

(1) Loiter on one GG
(2) 2 ft sink off bow

FIGURE 3-7
ASW MISSION BREAKDOWN
MULTIPURPOSE AIRCRAFT

	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	38,700					
Warmup, T.O., Accel to V_{Climb} 2 Min. Intermed. + 1/2 Min. T.O.		SL	-	500	-	0.04
	38,200					
Climb to BCAV at Intermed. Thrust			0.64	965	51	0.133
	37,235	35,660				
Cruise to Radius at BCAV			0.73	805	99	0.23
	36,430	35,800				
Descent to 10,000 Ft, No Credit			-	-	-	-
	36,430					
Loiter Speed for Best Endurance (Drop Tanks when Empty)		10,000	0.38	9487	-	3.15
	26,458					
Climb to BCAV at Intermed. Thrust			0.65	412	24	0.06
	26,046	36,089				
Cruise to Starting Point at BCAV			0.71	745	126	0.31
	25,301	36,089				
Descent to Sea Level, No Credit			-	-	-	-
	25,301					
Landing Allowance and Reserves		SL				
10 Min Loiter Best End.			0.28	493	-	0.167
5% Total Initial Fuel			-	706		
TOTAL				14,113	300	4.10

Notes: 5 Percent Fuel Flow Tolerance Included.
Two GG Operation for all Mission Segments.

FIGURE 3-8

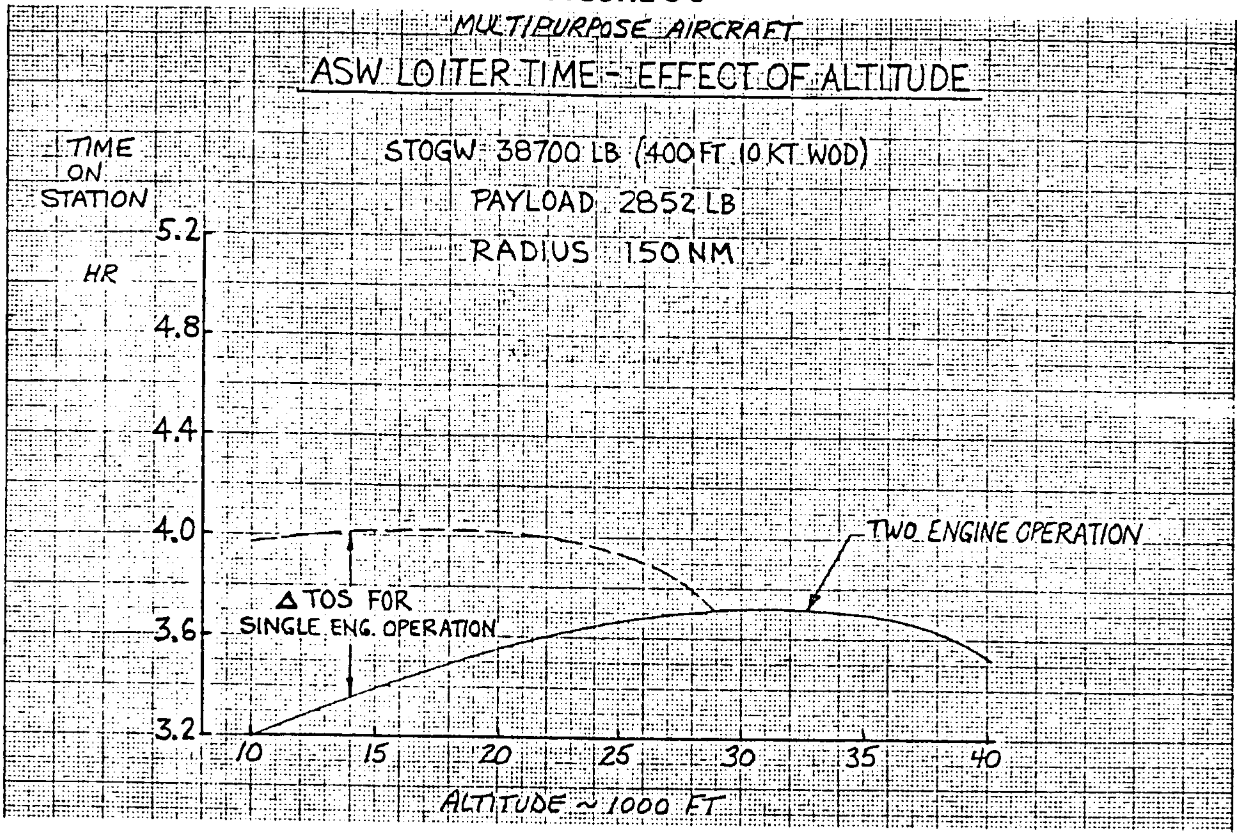


FIGURE 3-9

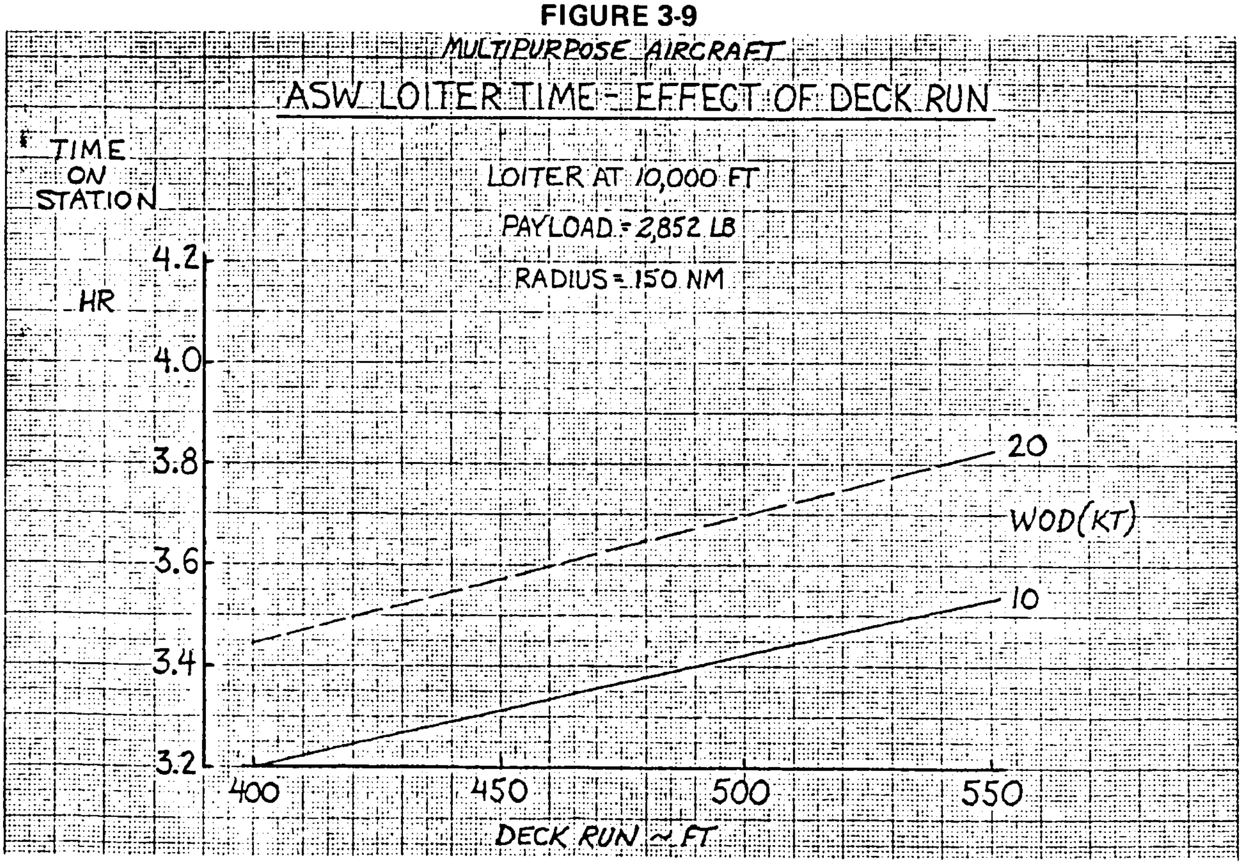


FIGURE 3-10

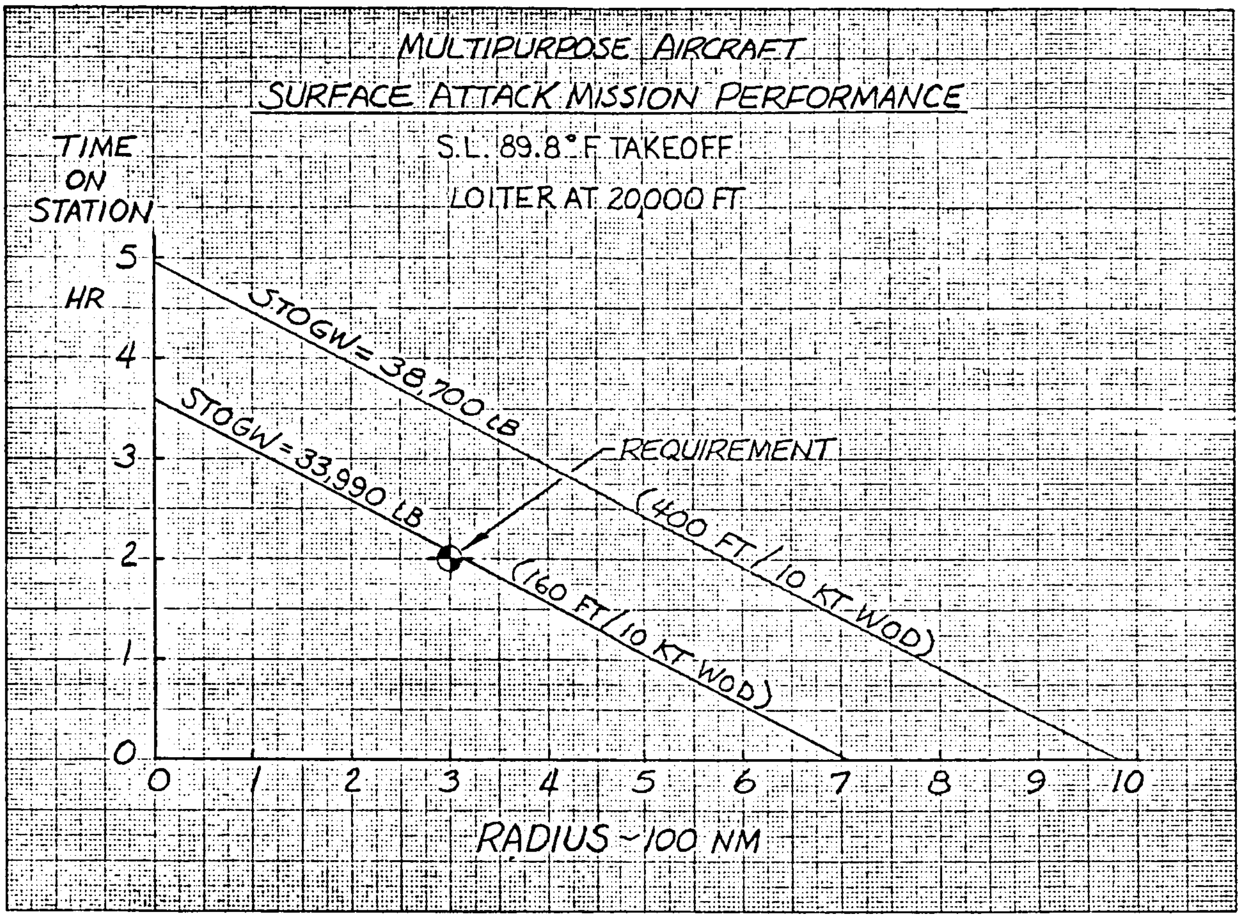


FIGURE 3-11
SA MISSION CAPABILITY - MULTIPURPOSE AIRCRAFT

PERFORMANCE		REQUIREMENT	NAVY MISSION	ALTERNATE CAPABILITY
STOGW	(LB)	-	33,990	38,700
DECK ROLL	(FT)	400	160	400
WOD	(KT)	10	10	10
PAYLOAD	(LB)	2712	2712	2712
RADIUS	(NM)	300	300	300
LOITER TOS	(HR)	2	2	3.4
ALTITUDE	(FT)	20000	20000	20000
ENGINE OUT LANDING		VL	VL	VL

FIGURE 3-12
SA MISSION BREAKDOWN
MULTIPURPOSE AIRCRAFT

MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	33,990					
Warmup, T.O., Accel To V_{Climb} 2 Min. Interm. + 1/2 Min. T.O.		SL	-	500	-	0.042
	33,490					
Climb: TO BCAV at Intermed. Thrust			0.64	760	40	0.103
	32,730	36,090				
Cruise: To Radius at BCAV			0.73	1782	260	0.625
	30,948	36,090				
Descend: To 20,000 Ft., No Credit			-	-	-	-
	30,948					
Loiter: 2 Hours at 20,000 Ft.		20,000	0.44	5023	-	2.045
	25,925					
Combat: 5 Min at Intermediate 20,000 Ft. M = 0.8		20,000	0.80	730	-	0.083
	25,195					
Climb: From 20,000 Ft to BCAV Intermediate Thrust			0.68	249	17	0.042
	24,946	36,090				
Cruise: Return at BCAV			0.70	1602	283	0.710
	23,344	36,090				
Descend: To Sea Level, No Credit						
	23,344		-	-	-	-
Landing Allowance and Reserves:		SL				
10 Min Loiter Best End.			0.27	470	-	0.167
5% Total Initial Fuel			-	585	-	-
	22,289					
				11,700	600	3.82

Note: 5 Percent Fuel Flow Tolerance included.

FIGURE 3-13

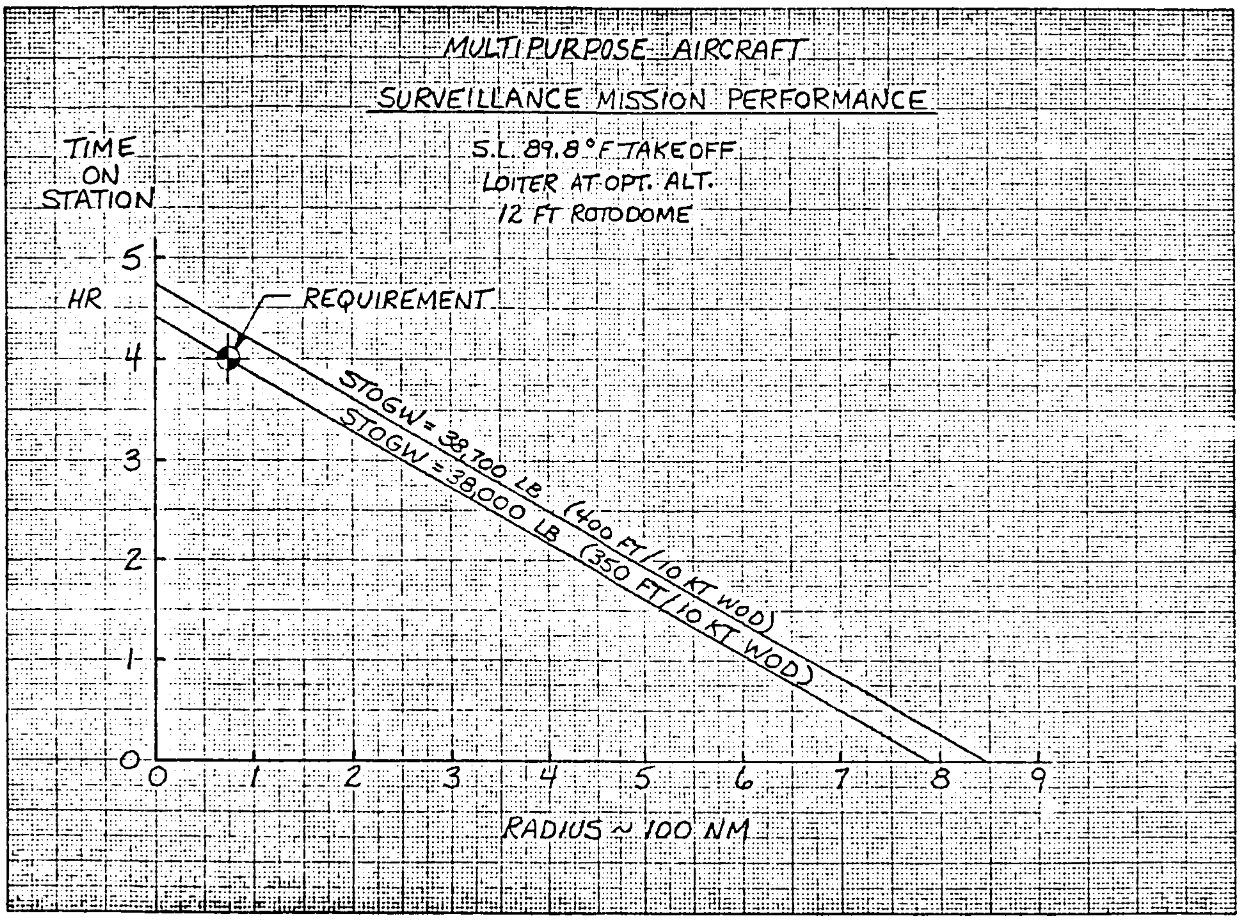


FIGURE 3-14
SURV MISSION CAPABILITY
MULTIPURPOSE AIRCRAFT

PERFORMANCE		REQUIREMENT	NAVY MISSION	ALTERNATE CAPABILITY
STOGW		-	38,000	38,700
DECK ROLL	(FT)	400	350	400
WOD	(KT)	10	10	10
AVIONICS WEIGHT	(LB)	NOT SPECIFIED	6237	6237
RADIUS	(NM)	75	75	75
LOITER TOS	(HR)	4	4	4.3
ALTITUDE	(FT)	OPT	OPT	OPT
ENGINE OUT LANDING		RVL (2)	RVL (1)	RVL (1)

(1) RVL = ROLLING VERTICAL LANDING: 100 FT DECK ROLL WITH 10 KT WOD, OR 50 FT WITH 20 KT WOD.
(2) AS APPROVED FOR COMMONALITY APPROACH.

FIGURE 3-15
SURV MISSION BREAKDOWN
MULTIPURPOSE AIRCRAFT

MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	38,000					
Warmup, T.O., Accel to V_{Climb} 2 Min. Intermed. + 1/2 Min T.O.		SL	-	500	-	0.04
	37,500					
Climb: To BCAV at Intermediate Thrust			0.63	955	50	0.13
	36,545	35,680				
Cruise: To Radius at BCAV			0.72	205	25	0.06
	36,340					
Loiter: On Station 4 Hrs at Best Endurance, 25,000 Ft or Higher		33,920	0.59	10,569	-	4.00
	25,771					
Cruise: To Point of Takeoff BCAV			0.68	464	75	0.19
	25,307	36,089				
Descend: To Sea Level, No Credit			-	-	-	-
	25,307					
Landing Allowance and Reserved:		SL				
10 Min Loiter, Best End.			0.27	496	-	0.17
5% Total Initial Fuel			-	694	-	-
	24,117					
TOTAL				13,883	150	4.60

Notes: 5 Percent Fuel Flow Tolerance Included.
Two GG Operation for all Mission Segments

Combat Search and Rescue (CSAR)

Figure 3-16 presents the CSAR mission performance for the aircraft armed with two AIM-9 missiles and a minigun plus 1000 rounds of ammo. The mission requirements can be met with a STOGW of 31,300 lb and a takeoff distance of 100 ft 10 kt WOD. For weight saving and aircraft commonality, the low altitude dash Mach number for the sea level, 50 nm, segment is limited to 400 KEAS (M = 0.6 at S.L., standard day). Increasing the speed to M = 0.8 at S.L. would require 540 lb of structural weight but is possible if desired since the aircraft is not thrust limited until 0.83 Mach number is reached. The M = 0.6 speed is approximately 2.5 to 3 times the current helicopter rescue speed capability. Except for the sea level M = 0.8 to M = 0.6 deviation, the CSAR mission profile and general discussion are the same as given in Section 1.

A midpoint hover time in excess of 20 minutes is available at the required radius of 400 nm at a STOGW of 33,500 lb. The specified 10-minute hover period is possible at 650 nm radius with a STOGW of 35,350 lb (220 ft deck run, 10 kt WOD) or at 300 nm radius with an initial vertical takeoff. If the rescue area permits VL/VTO operation, a rescue at 900 nm is possible with an initial STOGW of 37,000 lb (<300 ft takeoff 10 kt WOD). In all rescue cases the midpoint hover period was initiated at the gross weight level permitted by the gas generator intermediate dry rating, S.L. 89.8°F day and as fuel is burned, two 200 lb evacuees are hoisted aboard. A greater number of evacuees, ultimately limited by the pounds of fuel burned during the hover period, can be rescued without significantly altering the radius capability. Figure 3-17 tabulates mission capabilities.

FIGURE 3-16

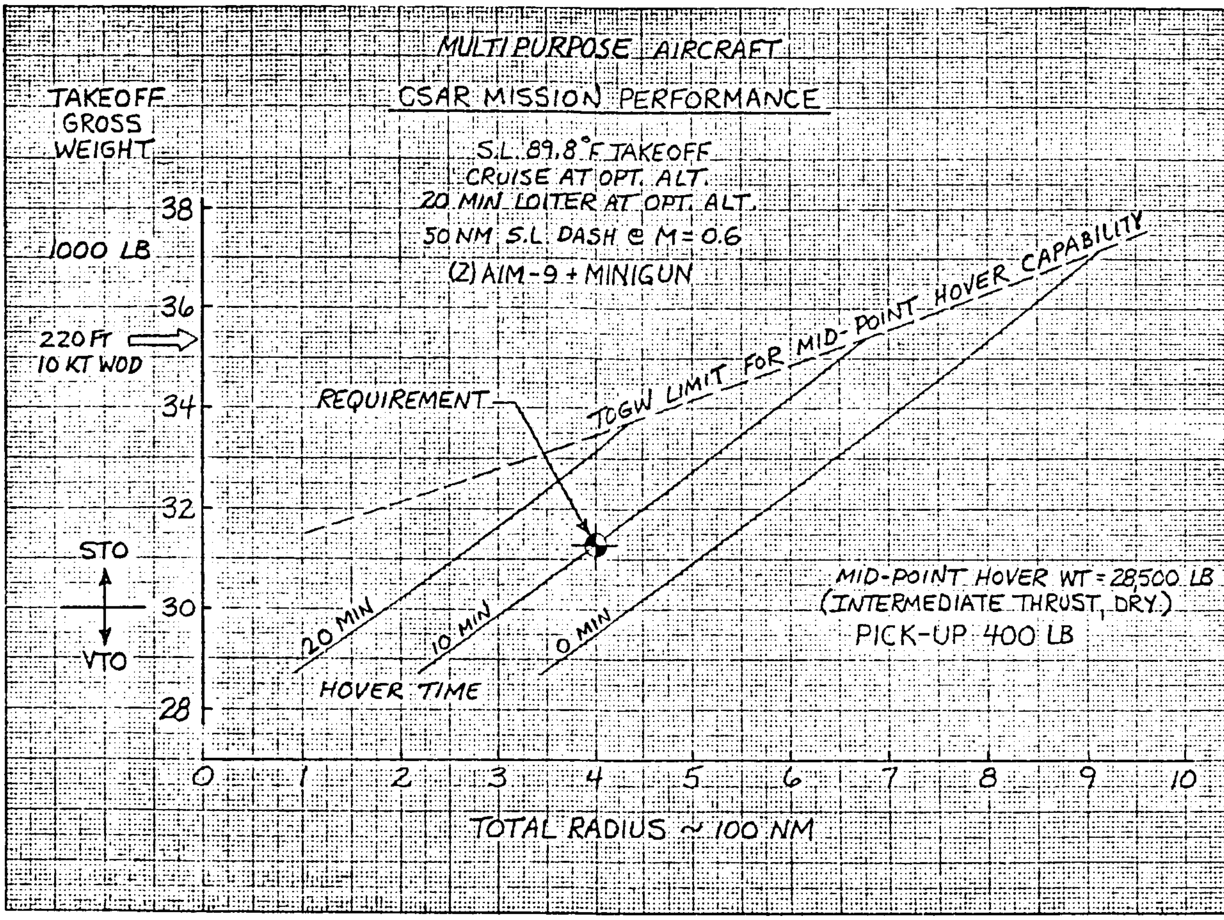


FIGURE 3-17
CSAR MISSION CAPABILITY
MULTIPURPOSE AIRCRAFT

PERFORMANCE		REQUIREMENT	NAVY MISSION	ALTERNATE CAPABILITY	
STOGW		-	31,300	35,400	38,700
DECK ROLL	(FT)	400	100	220	400
WOD	(KT)	10	10	10	10
S.L. DASH MACH NO.	(50 NM)	0.80	0.60	0.60	0.60
LOADING	(LB)				
(2) AIM-9		380	380	380	380
MINIGUN + 1000 RDS		221	221	221	221
ARMOR		600	600	600	600
RADIUS	(NM)	400	400	675	400
LOITER TOS	(MIN)	20	20	20	115
MID-PT HOVER TIME	(MIN)	10	10	10	20
LOAD PICKUP	(LB)	400	400	400	400
ENGINE OUT LANDING		VL	VL	VL	VL

Figure 3-18 shows the pre-dash, optimum altitude loiter time-radius capabilities while retaining a 10-minute hover period using the takeoff gross weight (38,700 lb) permitted by 400 ft deck roll, 10 kt WOD. At 400 nm total radius the TOS is 8 times the 20-minute requirement; at 675 nm, the TOS is 4 times the requirement. The rescue aircraft speed and extended loiter periods would permit accompaniment with the strike force to within 50 nm of the target with standby capability for alert of a downed attack aircraft. Alternatively, the increased fuel could be used at a reduced loiter altitude to avoid detection or to provide a search period in the rescue area prior to the actual recovery.

Figure 3-19 presents the interchange of loiter time at optimum altitude and hover time at S.L. 89.8°F day at 400 nm total radius, again for the 38,700 lb STOGW (400 ft deck roll, 10 kt WOD). Hover time increases over the required 10-minute period are indicative of a rescue potential at greater altitudes or temperatures than specified.

Figure 3-20 presents the mission breakdown at the gross weight (31,300 lb) required to meet the specified CSAR requirement. The midpoint arrival gross weight is 26,544 lb and the total mission time is 2.7 hours. In a tropical day atmosphere, the hover capability at 26,544 lb and intermediate dry thrust rating is approximately 2700 ft. Intermediate thrust rating is used for all midpoint hovering because the 10-minute requirement excludes use of the short term, higher ratings. However, the use of short term ratings for VL or rolling vertical landing would permit rescue at even greater altitude.

FIGURE 3-18

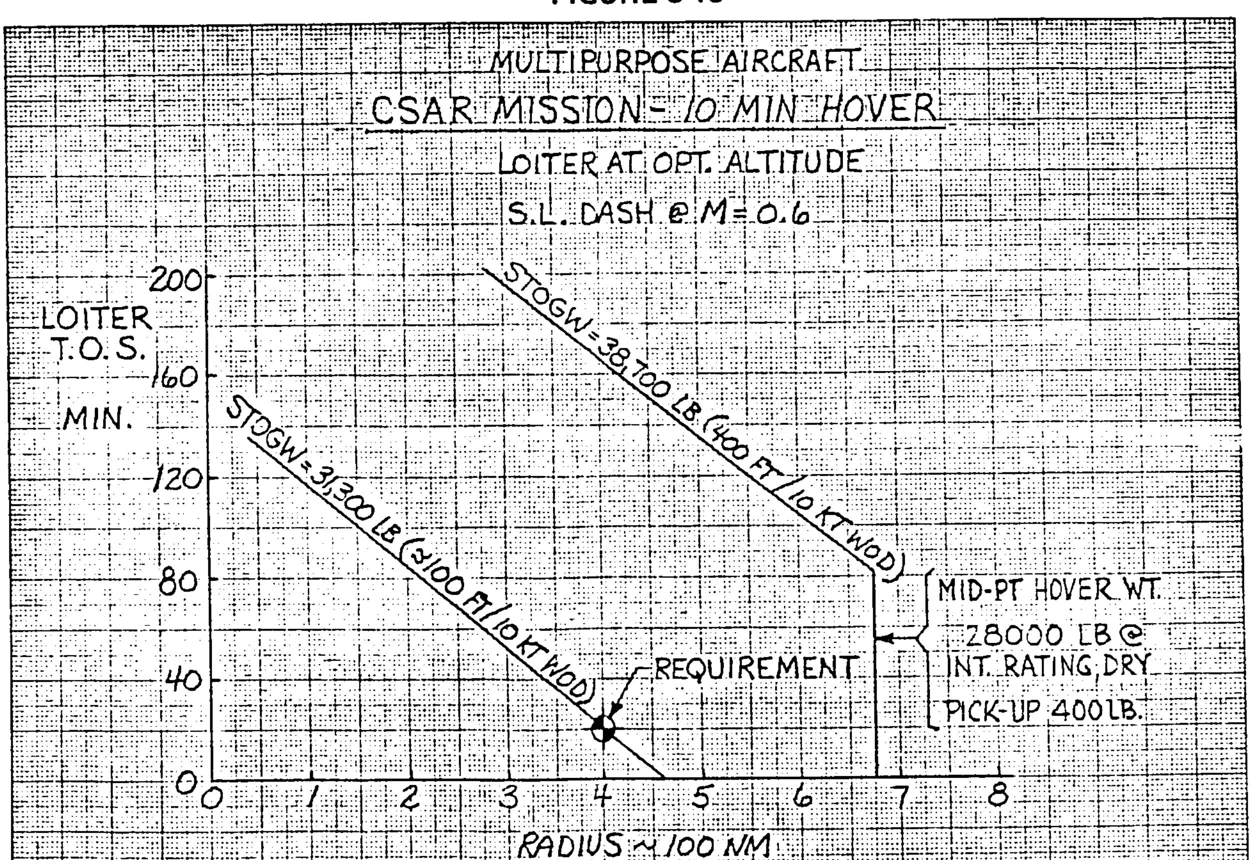


FIGURE 3-19

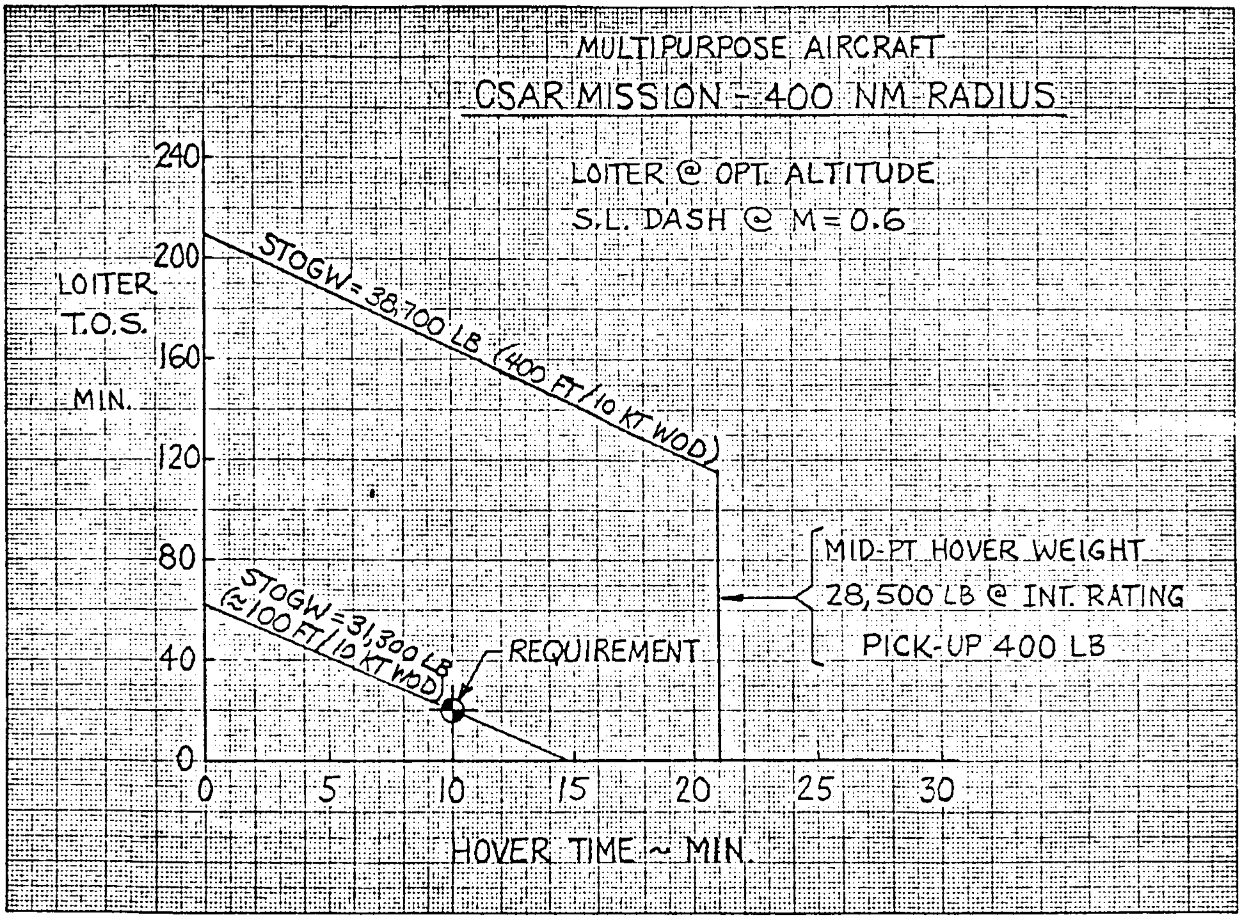

MULTIPURPOSE AIRCRAFT
CSAR MISSION - 400 NM RADIUS
LOITER @ OPT. ALTITUDE
S.L. DASH @ M=0.6
LOITER T.O.S. MIN.
240
200
160
120
80
40
0
STOGW = 38,700 LB (400 FT/10 KT WOD)
STOGW = 31,300 LB (≈100 FT/10 KT WOD)
REQUIREMENT
MID-PT HOVER WEIGHT
28,500 LB @ INT. RATING
PICK-UP 400 LB
0
5
10
15
20
25
30
HOVER TIME ~ MIN.

FIGURE 3-20
CSAR MISSION BREAKDOWN
MULTIPURPOSE AIRCRAFT

MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	31,300					
Warmup, T.O., Accel to V_{Climb} 2 Min Intermediate + 1/2 Min T.O.		SL	-	500	-	0.042
	30,800					
Climb: To BCAV at Intermediate Thrust			0.64	667	35	0.090
	30,133	36,089				
Cruise: To 350 NM at BCAV			0.72	2005	315	0.764
	28,128					
Loiter: 20 Min at Opt Alt Best End		35,150	0.60	734	-	0.333
	27,394					
Descend: To Sea Level, No Credit			-	-	-	-
	27,394					
Dash: 50 NM at Sea Level, M = 0.6		SL	0.60	850	50	0.126
	26,544					
Hover: 10 Min at S.L. (OGE) Pick-up 400 Lb.		SL	-	1478	-	0.167
	25,466					
Dash: 50 NM at Sea Level, M = 0.6		SL	0.60	846	50	0.126
	24,620					
Climb: To BCAV at Intermediate Thrust			0.62	497	25	0.067
	24,123	36,090				
Cruise: At BCAV to Point of Takeoff			0.69	1800	325	0.826
	22,323	36,090				
Descend: To Sea Level, No Credit			-	-	-	-
	22,323					
Landing Allowance and Reserves:		SL				
10 Min Loiter Best Endurance			0.26	460	-	0.167
5% Total Initial Fuel	21,345		-	518	-	-
TOTALS				10,355	800	2.70

Note: 5 Percent Fuel Flow Tolerance Included.

Vertical On Board Delivery (VOD)

The VOD multipurpose design is a production line modification using a larger fuselage. In addition to the cargo fuselage substitution, a third engine was installed to provide emergency VL capability with assault troop/passenger loadings. Existing J97 generators (70 lb/sec gas flow) were directed by NASA/Navy for use in the VOD multipurpose aircraft. Figure 3-21 presents the disposable payload-range performance at the NASA/Navy directed 45,000 lb gross weight limit which meets the 5000 lb-2000 nm mission requirement. This gross weight is achieved with a 400 ft deck roll, 20 kt WOD and all three gas generators operating. Figure 3-22 presents the mission breakdown at a gross weight of 45,000 lb. A reduction of the mission gross weight through adaptation of 10-minute rather than a 20-minute reserve fuel loiter time is sufficient to give the full 2000 nm range on less than internal fuel (18,000 lb). All cruise and loiter operations are with two gas generator operation; the third engine is used only for takeoff to wingborne flight or for vertical landing.

In addition to the three existing J97 gas generators (70 lb/sec) VOD configuration, there are two other possible configurations either in a two or a three gas generator version using growth J97 (80 lb/sec) gas generators. A two 80 lb/sec gas generator configuration was evaluated as an alternate VOD multipurpose aircraft. Figure 3-23 presents the alternate VOD mission performance of payload as a function of range for two STO gross weight levels. The VOD payload-range requirement (5000 lb at 2000 nm) can be fulfilled at 43,000 lb STOGW requiring either a 150 ft greater deck roll or a 15 kt greater WOD. The 5000 lb payload can be transported 1860 nm, for the specified takeoff criterion of 450 ft, 20 kt WOD (STOGW = 41,500 lb). Rolling vertical landings of less than 100 ft are required for the two 80 lb/sec gas generator configuration with one gas generator inoperative. The three 80 lb/sec gas generator configurations provides exceptional V/STO and VL performance. The VOD aircraft can take-off at 50,000 lb STOGW, using 400 ft deck run and 10 kt WOD, and deliver 5000 lbs payload to a range of 2300 nm. An engine out vertical landing can also be made with 23 fully equipped assault troops (5520 lb) on board. Figure 3-24 tabulates mission capabilities for the three existing J97 (70 lb/sec) and the alternate two and three growth J97 (80 lb/sec) gas generator VOD configuration.

FIGURE 3-21

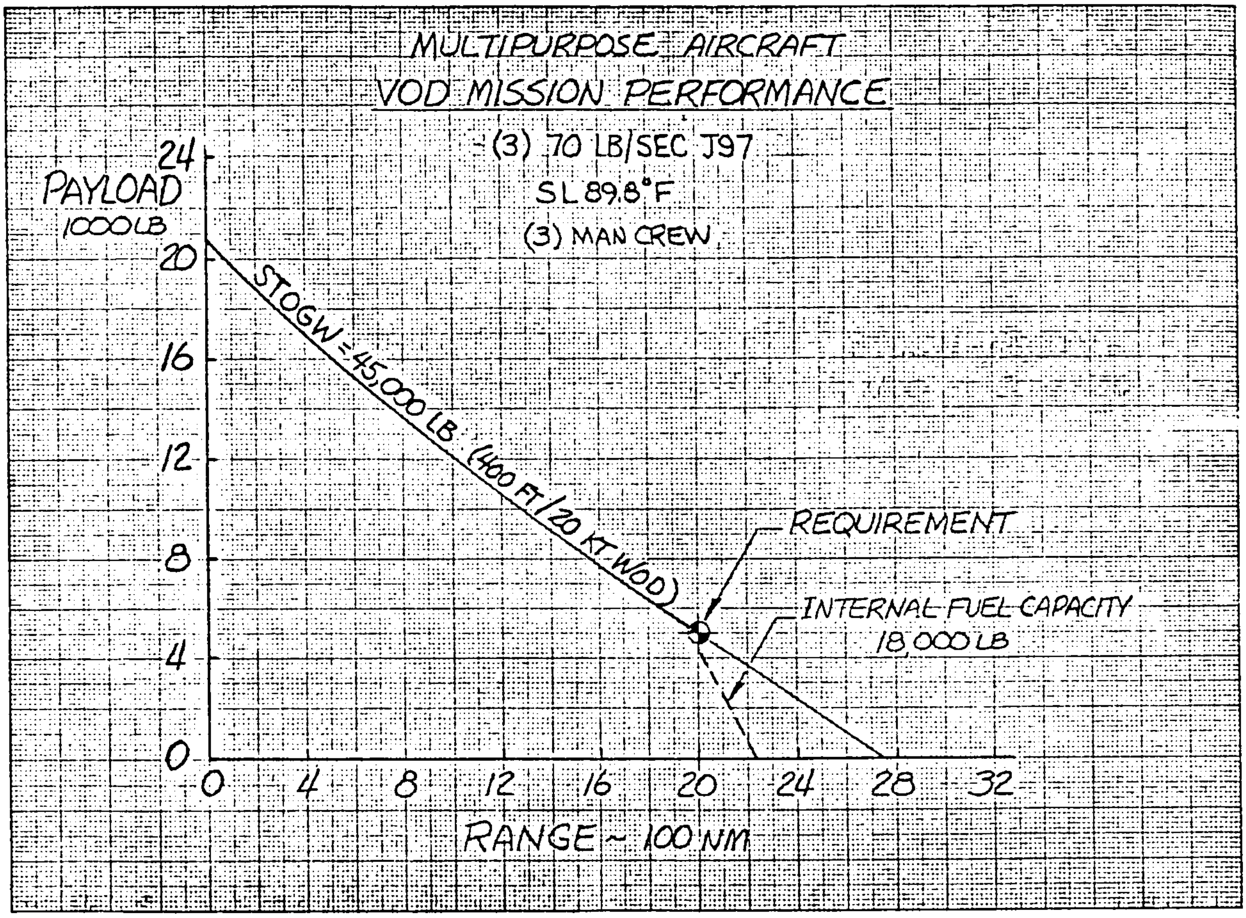


FIGURE 3-22
VOD MISSION BREAKDOWN
MULTIPURPOSE AIRCRAFT

MISSION SEGMENT/BREAKDOWN	G.W. (LB)	ALT. (FT)	MACH	FUEL (LB)	DIST (NM)	TIME (HR)
	45,000					
Warmup, T.O., Accel to V_{Climb} 2 Min Interm + 1/2 Min T.O.		SL	-	645	-	0.042
	44,345					
Climb to BCAV at Intermediate Thrust			0.59	1376	82	0.227
	42,969	32,390				
Cruise BCAV			0.72	14,594	1918	4.640
	28,385	36,089				
Descend to Sea Level, No Credit			-	-	-	-
	28,385					
Landing Allowance and Reserves:		SL				
20 Min Loiter, Best Endurance			0.28	950	-	0.333
5% Total Initial Fuel			-	924	-	-
	26,511					
TOTAL				18,489	2000	5.24

Notes: 5 Percent Fuel Flow Tolerance Included
Mission Payload = 5000 Pounds

FIGURE 3-23

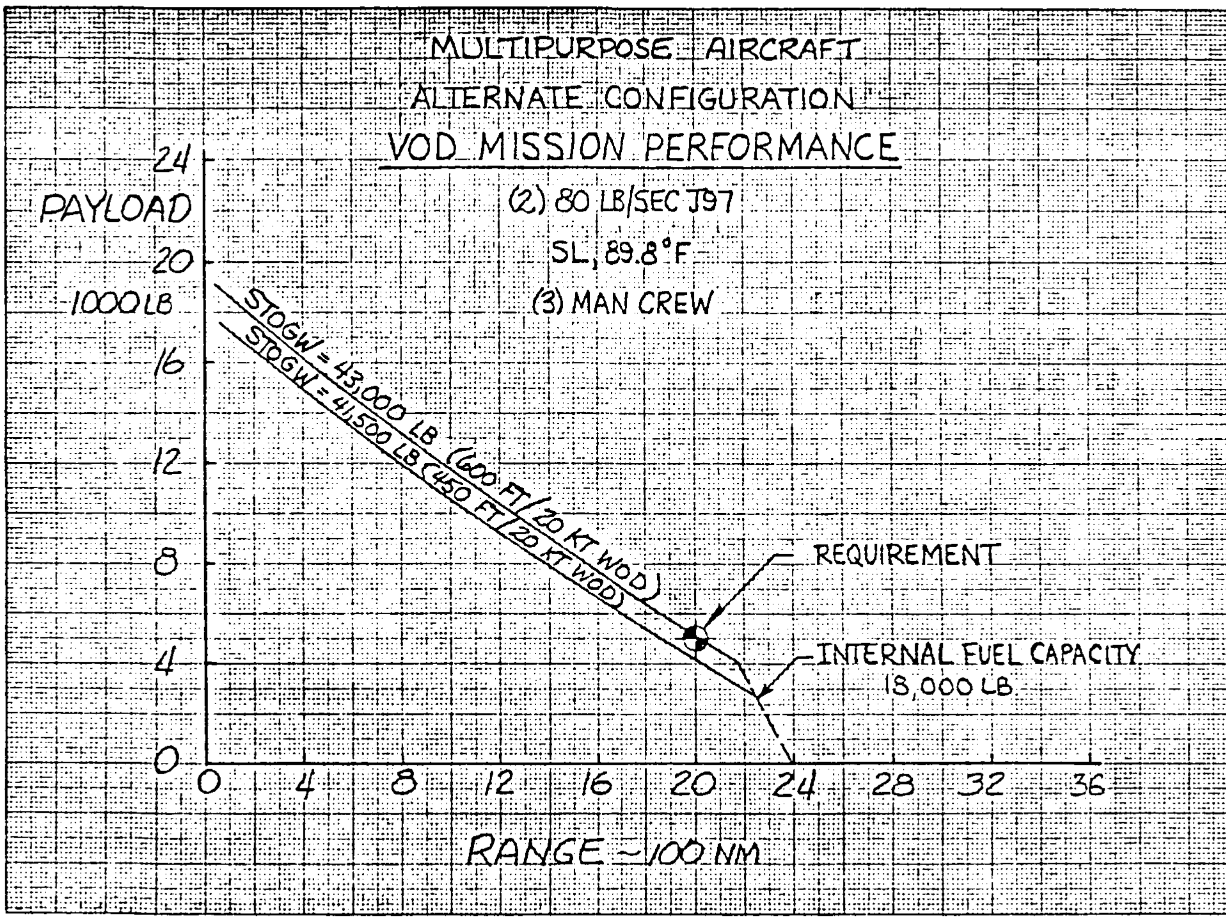

MULTIPURPOSE AIRCRAFT
ALTERNATE CONFIGURATION
VOD MISSION PERFORMANCE
(2) 80 LB/SEC J97
SL, 89.8°F
(3) MAN CREW
PAYLOAD
1000 LB
24
20
16
12
8
4
0
STOGW = 43,000 LB (600 FT/20 KT WOD)
STOGW = 41,500 LB (450 FT/20 KT WOD)
REQUIREMENT
INTERNAL FUEL CAPACITY
18,000 LB
0
4
8
12
16
20
24
28
32
36
RANGE ~ 100 NM

FIGURE 3-24
VOD MISSION CAPABILITY
MULTIPURPOSE AIRCRAFT

Performance		Requirement	Navy Mission	Alternate Capability			
			(3 Existing GG)	(2 Growth GG)			(3 Growth GG)
STOGW	(lb)	45,000(1)	45,000	41,500	41,500	43,000	50,000(1)
Deck Roll	(ft)	450	400	450	450	600	400
WOD	(kt)	20	20	20	20	20	10
Payload	(lb)	5000	5000	5000	4000	5000	5000
Range	(nm)	2000	2000	1850	2000	2000	2300
Engine Out Landing		VL	VL	RVL(2)	RVL(2)	RVL(2)	VL

(1) Not to exceed 45,000 without Navy approval.
(2) RVL = rolling vertical landing: 100 ft deck roll with 20 kt WOD.

3.3 PROPULSION

The missionized aircraft design studies resulted in a range of solutions, in terms of propulsion system size and lift rating, using the J97 and LF460 turbotip fan characteristics and technology as core propulsion components. Gas generator sizes from the 70 lb/sec airflow J97-GE-100 for the SURV and VOD aircraft up to an 86 lb/sec airflow growth derivative for the ASW were required. The single stage, 1.32 pressure ratio fans varied in size from 57-inch diameter for the SA to 61-inch diameter for the ASW aircraft. Flaring the compressor or adding a zero compressor stage were identified as ways to achieve gas generator growth.

The goal in this part of the study was to determine which of the potential growth derivatives could most effectively perform the five Navy missions in the Multipurpose Aircraft. The effectiveness of the J97 growth derivatives, in terms of improved performance, mission capability, and the estimated additional development cost, were evaluated along with mission variation to determine the best compromise between capability and propulsion component commonality. General Electric Company assisted by estimating the additional development costs associated with the approaches (TIT increase, flared compressor, and zero stage compressor) to increasing the J97 gas generator performance capability.

Sixteen-hundred degrees Fahrenheit (1600°F) was established as the maximum Exhaust Gas Temperature allowable commensurate with fan scroll design technology. Performance for the growth gas generator designs (flared compressor and zero stage) was estimated on the basis of holding intermediate power EGT constant at 1450°F (hot day) allowing a margin of 150°F for VTO (one minute) rating EGT and short term control transients. This approach allows an increase in Turbine-In-Temperature (TIT) as shown in Figure 3-25. The additional lift available with the increased TIT schedule is given in Figure 3-26. The estimated delta cost of development for the flared compressor and zero stage modifications, including an increase in TIT in each case, is shown on Figure 3-27. While zero staging offers more growth performance, the flared compressor modification offers more performance per dollar invested in development.

The ASW and SURV missions require gas generator growth. Figure 3-28, shows the zero stage modification would be required to fully comply with the ASW mission loiter time. Alternatives involving mission variations (higher loiter altitude, single engine loiter, increase STO roll to 415 ft) would allow use of the less costly flared compressor modification.

The SURV mission, Figure 3-29, with two gas generators, required a gas generator airflow growth in excess of the zero stage modification to meet the engine out vertical landing requirement. As discussed in Section 2, NASA/Navy approved an RVL for this mission which allowed the selection of the two flared compressor (80 lb/sec) configuration.

Engine out landing capability is the principal requirement influencing gas generator power requirements in the VOD mission. Figure 3-30, shows this requirement can be satisfied with a system employing 3 growth J97's (80 lb/sec) or 3 existing J97's. Alternate configurations, using two zero stage compressors or two flared compressors require an RVL of 40 and 100 feet respectively.

FIGURE 3-25
EXHAUST GAS TEMPERATURE

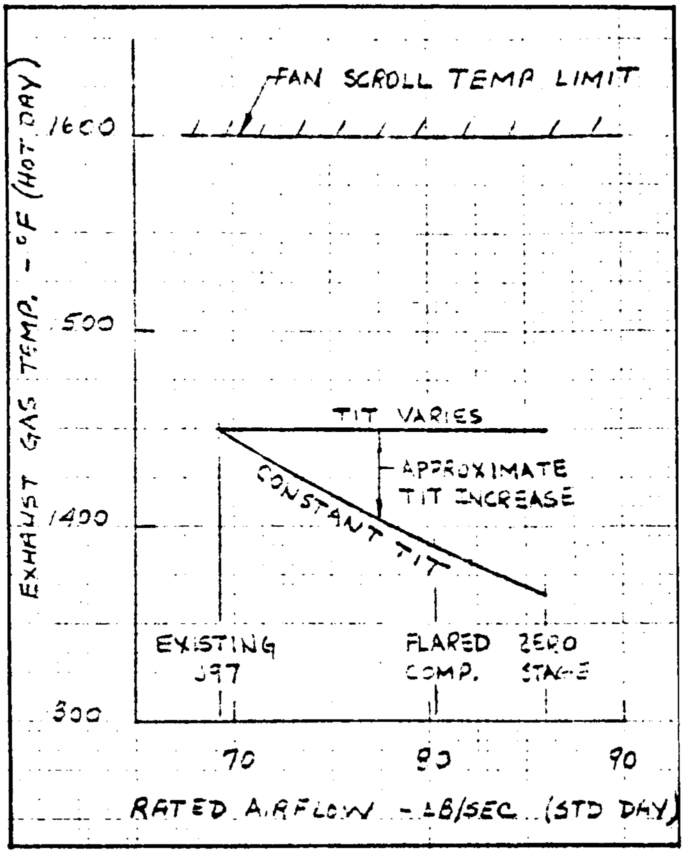


FIGURE 3-26
LIFT RATING INCREASE

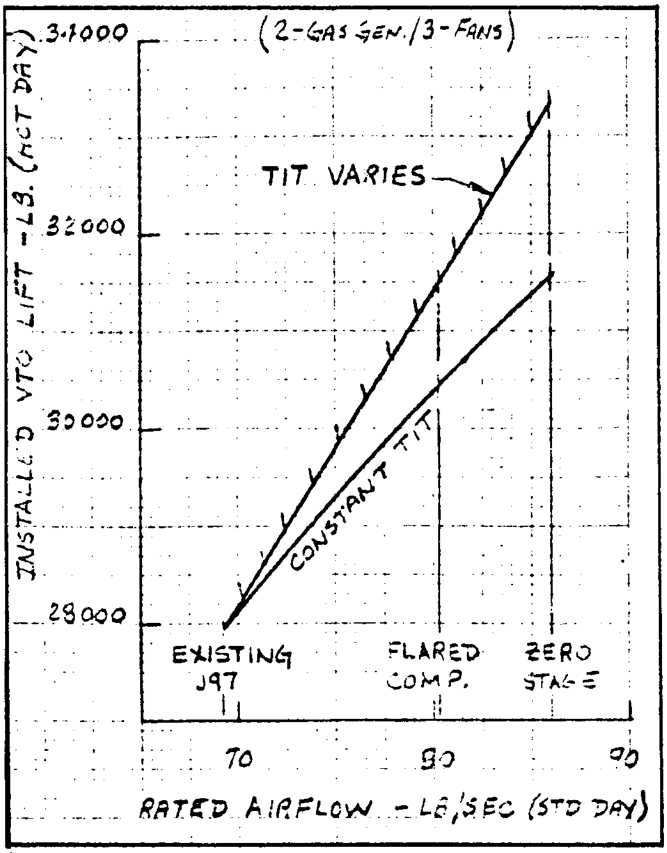


FIGURE 3-27
LIFT RATING DEVELOPMENT COST

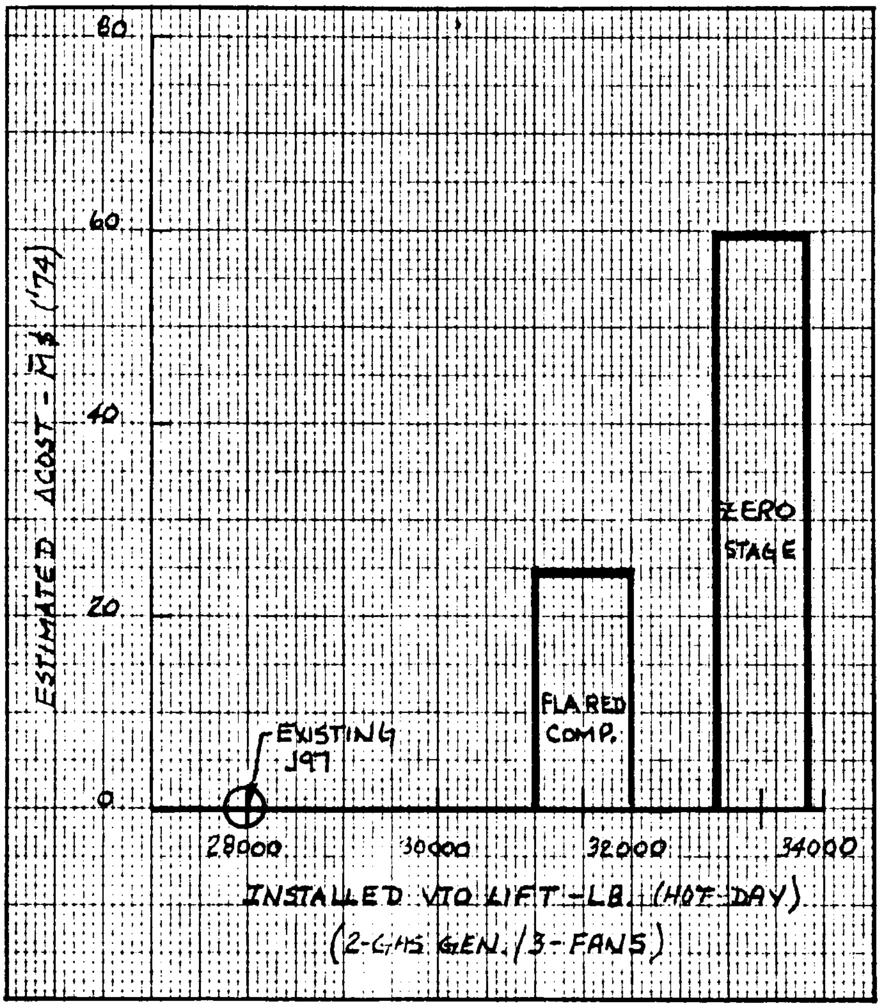


FIGURE 3-28
ASW MISSION

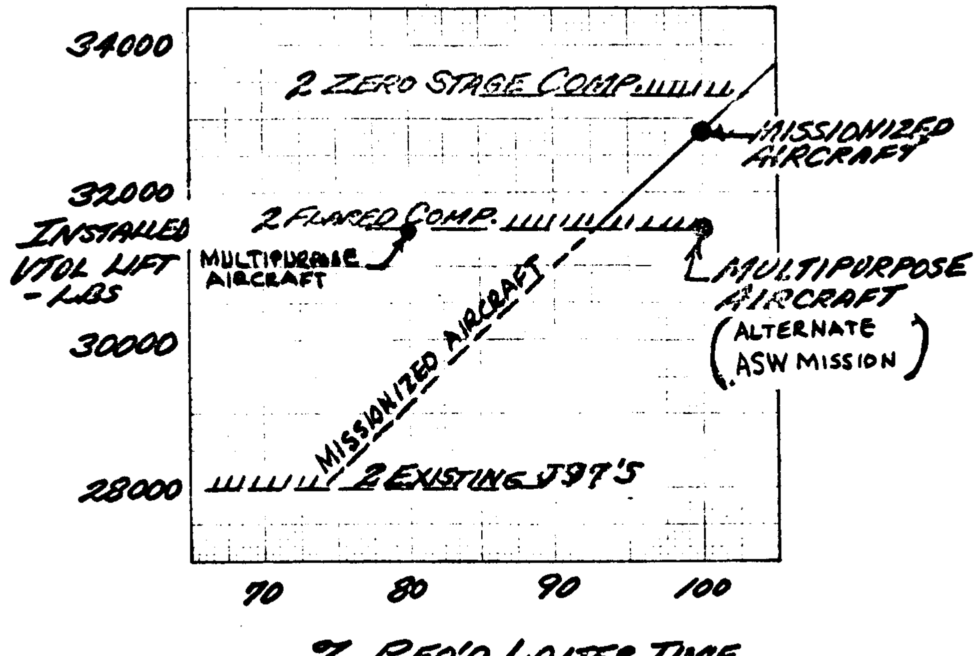


FIGURE 3-29
SURV MISSION

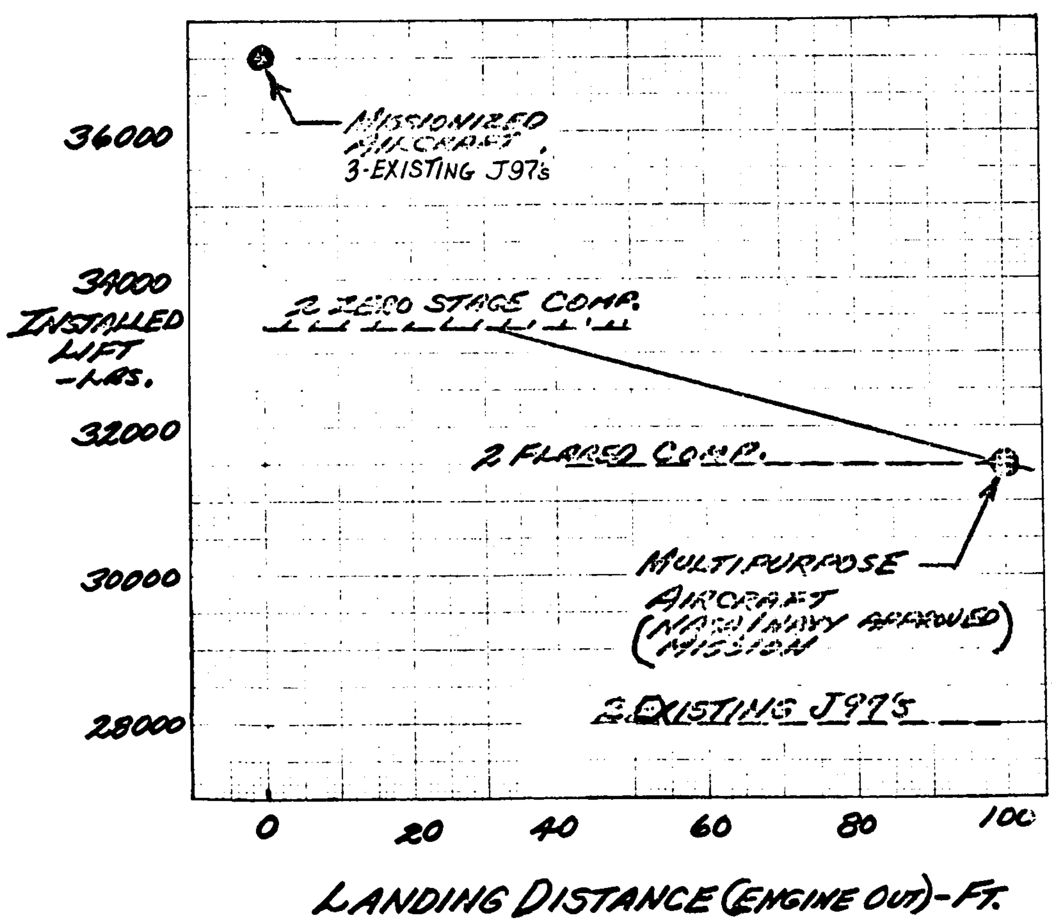


FIGURE 3-30
VOD MISSION

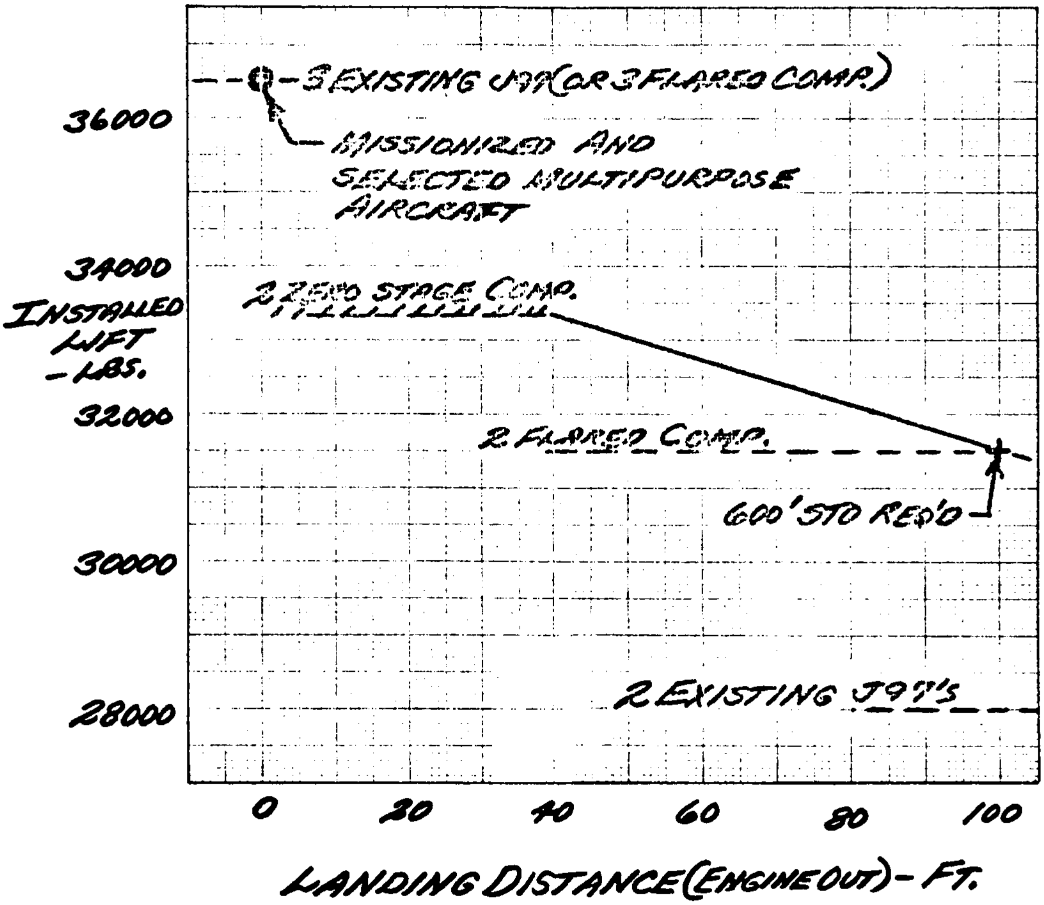


Figure 3-31, shows that use of a 59" diameter fan achieves the lift required when used with the selected flared compressor approach. Increasing fan diameter above 59 inches would still require gas generator growth, but would increase aircraft folded span, gross weight and cross-sectional area. Therefore, the minimum size fan (59" dia) capable of providing the required lift was selected.

It was concluded that selection of the growth J97 (80 lb/sec airflow rate flared compressor) and 59-inch diameter 1.32 pressure ratio turbotip fan would afford propulsion system component commonality in the multipurpose aircraft in the most effective, least costly, manner. Characteristics of the propulsion systems are summarized in Figure 3-32.

FIGURE 3-31
BEST FAN DIAMETER

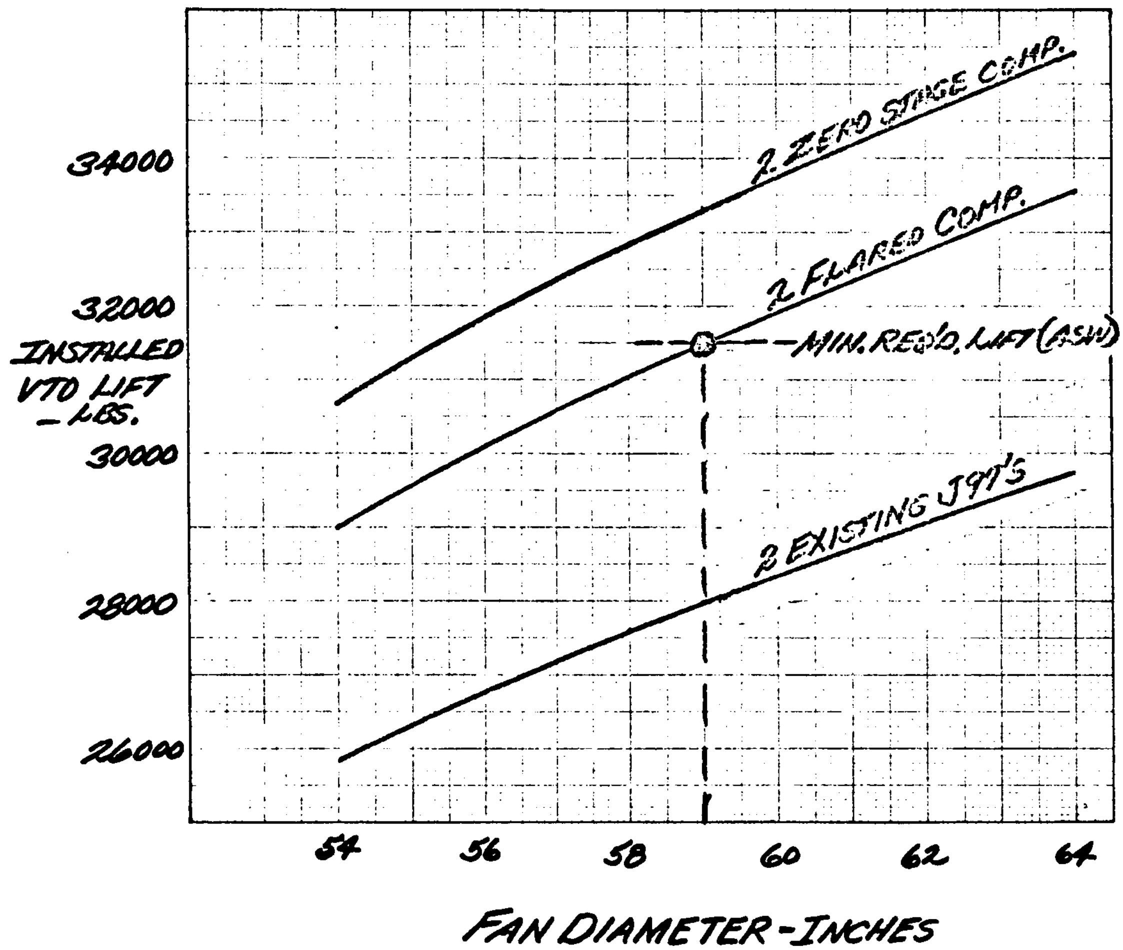


FIGURE 3-32
MULTIPURPOSE AIRCRAFT PROPULSION SYSTEMS

	ASW, SA, SURV, CSAR	VOD*
Gas Generators	Growth J97 (2)	J97-GE-100 (3)
Airflow Rating - lb/sec	80.3	69.2
Weight - lb	789	739
Fans	← LF 459 (3) →	
Airflow Rating - lb/sec	624	
Pressure Ratio	1.32	
Weight - lb	700	
Installed Lift - lbs		
S.L. Std Day		
VTO Rating, Dry	33,511	39,347
Emergency, Dry (1 Engine Out)	21,324	31,184
Emergency, Wet (1 Engine Out)	23,195	33,605**
S.L. 89.6°F		
VTO Rating, Dry	31,500	36,986
Emergency, Dry (1 Engine Out)	20,045	29,313
Emergency, Wet (1 Engine Out)	21,803	31,589**

*Three growth J97's can be used in place of three J97-GE-100's.

**Only dry ratings were used for the VOD, but this lift could be available with wet ratings.

3.4 AIRCRAFT CONTROL AND STABILITY

Aircraft control of all missionized and multimission configurations is similar enough to allow a single description of the control characteristics, requirements, and systems. The aircraft control description and analysis results are therefore presented only for the multimission aircraft.

General Considerations

The multimission aircraft is designed with ailerons, stabilator, and rudder for conventional roll, pitch and yaw control during aerodynamic flight. During VTOL powered lift, the aircraft is controlled by means of fan thrust modulation and vectoring. Thrust of the forward fan is modulated in opposition to the lift/cruise fans for pitch control, and the lift/cruise fans are differentially modulated for roll control. Fan thrust increase is accomplished by the Energy Transfer and Control (ETaC) system, while the Thrust Reduction Modulation (TRM) system is used for thrust decrease. The TRM system is a set of mechanical thrust spoilers which operate in harmony with the ETaC system for very effective and responsive differential thrust modulation. Vectoring the thrust of the forward fan laterally, but in a direction opposite to the lateral lift/cruise fan vectors, provides aircraft moments for yaw control. During transition the aerodynamic controls and the powered lift controls operate simultaneously and are naturally blended for effective aircraft control.

Height control in hover and low speed is provided by means of the engine throttles resulting in direct variation of fan produced lift. Transition is controlled by collectively vectoring the thrust of all fans in the forward and aft directions.

Aircraft Control Design Guidelines

Aircraft control requirements are identified according to the NASA/Navy study guidelines, and the specifications of MIL-F-83300 and MIL-F-8785. At this stage of design definition of the multimission aircraft, the primary control requirements are those of attitude control power, stability, and control response in the powered lift flight regime. Aircraft stability and control power are interrelated in that the control power requirements are affected by stability augmentation systems in hover and low speeds, and therefore a combination of NASA and MIL-F-83300 guidelines is used to set the control power design levels. Figure 3-33 shows the hover stability criteria which dictate the need for pitch and roll attitude stabilization systems with gains designed to provide a specific damping and natural frequency for satisfactory handling qualities. Typical unaugmented characteristics are also indicated for comparison.

The critical specification in MIL-F-83300 which determines the attitude control power requirement, is the attitude change in one second per inch of control displacement. Roll and pitch control powers were determined based on the above requirement using an attitude command control system designed to the desired closed loop frequency and damping characteristics of Figure 3-33. Yaw control power was determined based on a yaw rate command system with a damping of 1.0 sec^{-1} and a MIL-F-83300 specified angle in one second per inch of control displacement. The resulting control power requirements determined for the multimission aircraft are presented in Figure 3-34.

FIGURE 3-33
HOVER STABILITY CRITERIA

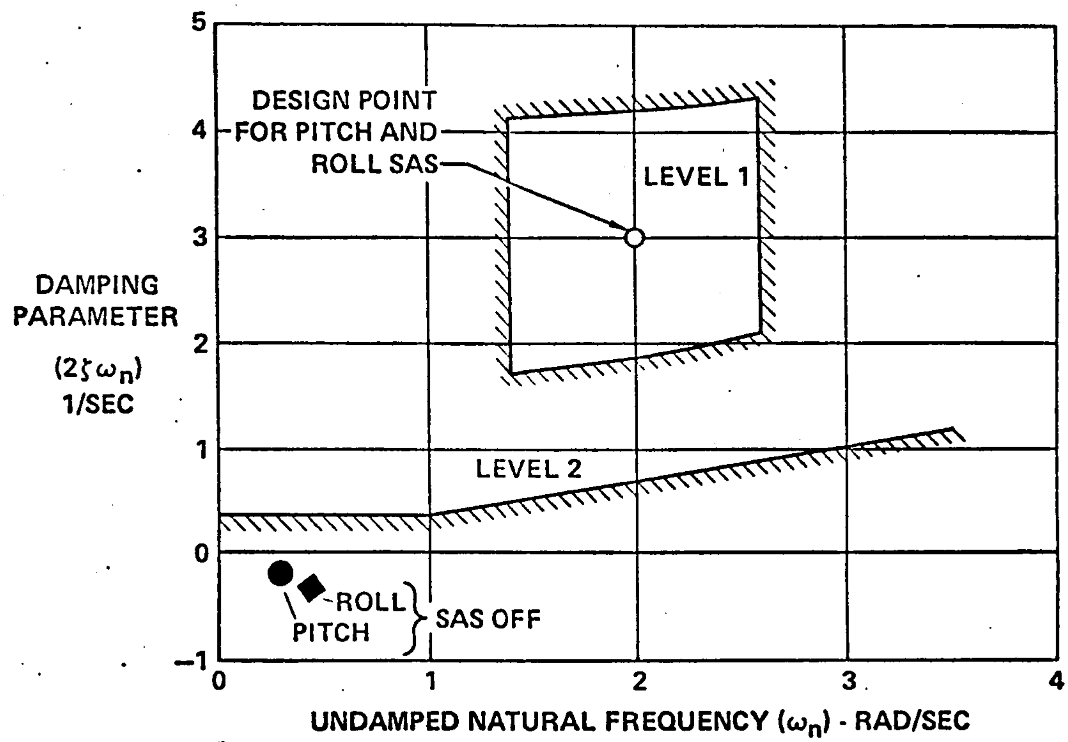


FIGURE 3-34
VTOL MANEUVER CONTROL POWER

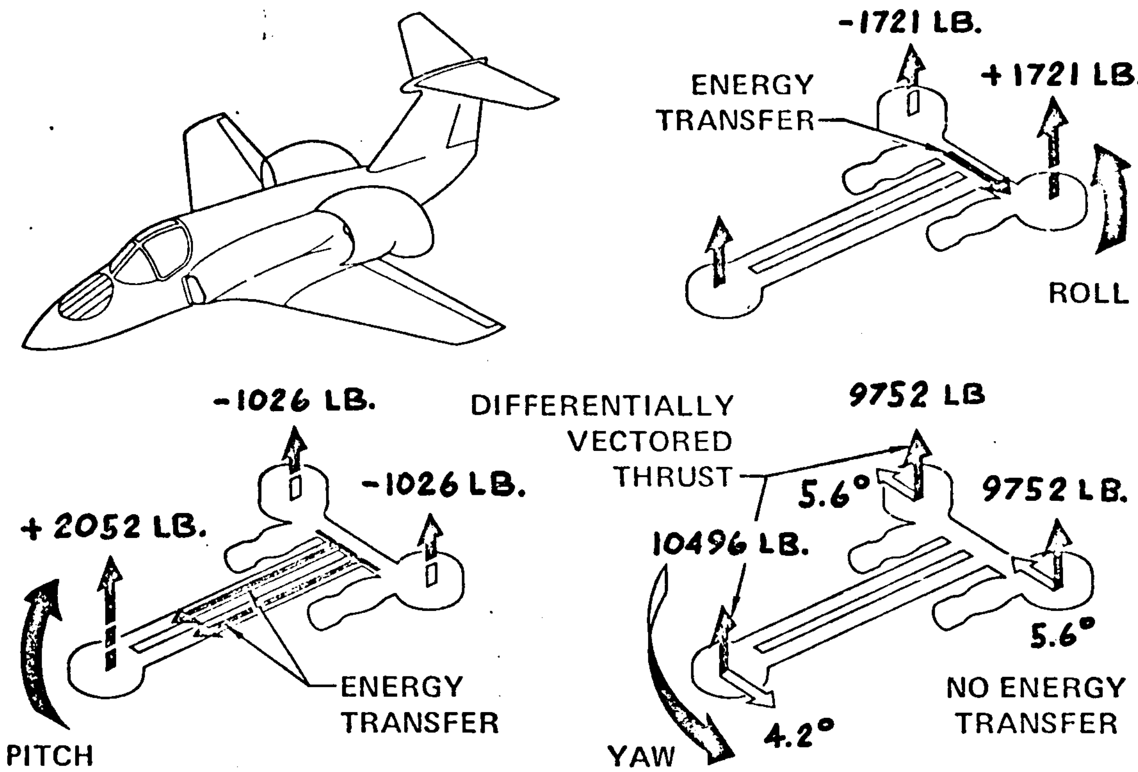
	* A/C ANGLE	CONTROL POWER REQ'D
ROLL	4.0°	1.2 RAD/SEC^2
PITCH	3.0°	1.0 RAD/SEC^2
YAW	6.0°	0.5 RAD/SEC^2

* ACHIEVE ANGLE IN 1 SEC PER 1 INCH CONTROL DISPLACEMENT PER MIL-F-83300

Thrust Modulation for Control

The thrust modulation levels and deflection angles required to satisfy the control power requirements at 30,000 pounds VTOGW were calculated and are presented in Figure 3-35. In the roll and pitch axes, the thrust modulation levels were determined to eliminate any cross-axis control coupling. The relative forward and aft fan thrust deflections for yaw were determined to maintain zero side force up to 40 percent of maximum yaw input. Beyond this point the additional 60 percent is generated by increased deflection of the lift/cruise fan thrust only. This

FIGURE 3-35
VTOL CONTROL
VTOGW - 30,000 Lb

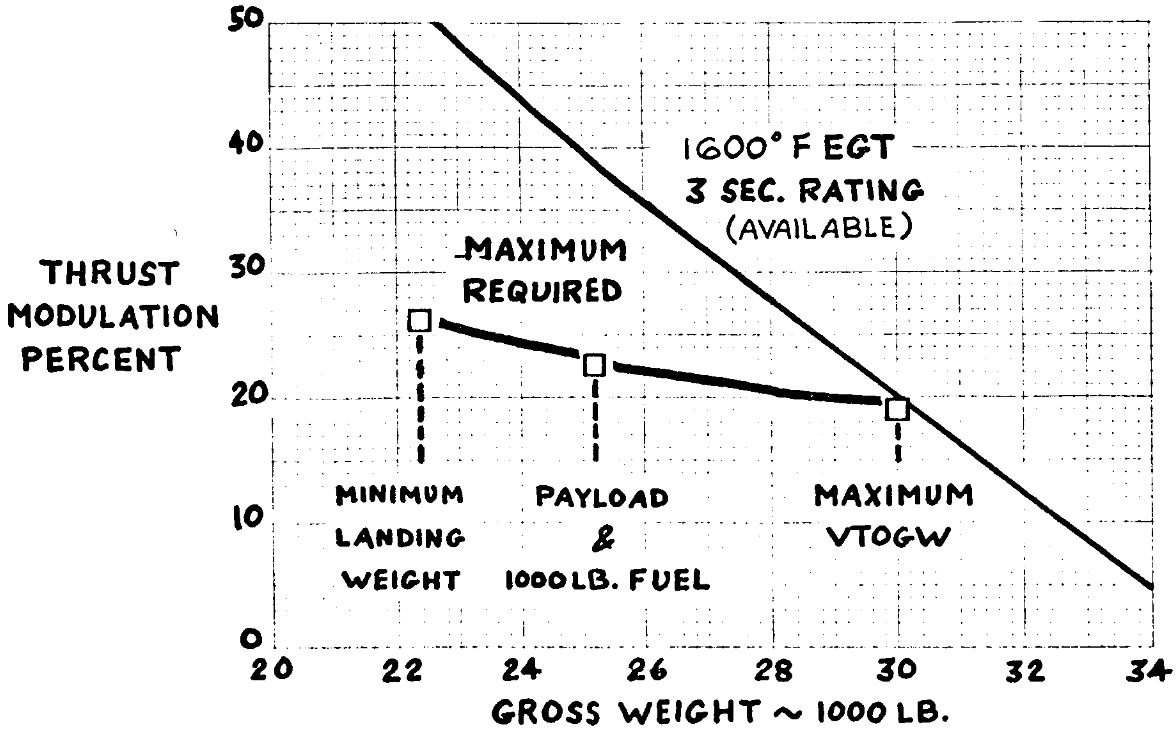


technique provides high overall yaw control power at low thrust deflection angles in transition, and still maintains a high level of pure yaw moment for hover, i.e. without side force coupling.

For the 30,000 pound VTOGW, pitch trim in hover is achieved by proper selection of gas flow split between the forward and aft fans. This results in a higher thrust level on the lift fan than on the lift/cruise fans as shown in Figure 3-35. By using gas flow split rather than ETaC, the aircraft can be trimmed without a corresponding increase in steady state gas generator EGT. At the landing gross weights and correspondingly lower EGT, when the c.g. location shifts from the center of lift, pitch trim in hover is achieved by means of gas energy transfer (ETaC).

Figure 3-36, shows both the required and the available thrust modulation in hover as a function of gross weight. The nose fan maximum thrust modulation requirement results from pitch trim added to full pitch control input. The lift/cruise fan thrust modulation requirements were determined based on pitch trim plus combined roll and pitch inputs. The lift/cruise fan thrust modulation is lower than the thrust modulation of the nose fan. The use of ETaC is not required to trim the aircraft at maximum TOGW. Once the forward/aft flow split was selected, it remained constant for the operational range of weights. The ETaC system is used to trim at lower thrust levels and is included in the modulation requirement curve in Figure 3-36. The available thrust modulation level is represented by a three second rating at 1600°F EGT of the uprated J97 gas generator.

FIGURE 3-36
ASW CONFIGURATION THRUST MODULATION FOR CONTROL



Control In Transition

Control powers in transition were determined for the multimission airplane at a 30,000 lb VTOGW with the thrust level and thrust vector angle selected to trim the airplane in level flight at zero angle of attack. Pitch control power variation with airspeed is shown in Figure 3-37.

To maintain a constant relationship between ETaC valve angle and control input, it is necessary to select the maximum ETaC valve angle, corresponding to maximum control input, at the minimum thrust setting. Once the maximum valve angles are selected, they remain constant for all thrust settings. As a result, the installed control power increases with increasing thrust until it becomes limited by the 1600°F, three second rating. The trim thrust level increases with decreasing speed and the thrust modulation control power increases with decreasing speed down to about 40 knots. Below 40 knots the control power is limited by gas generator EGT. Also, at higher transition speeds, the thrust modulation control power is reduced due to the increased thrust vector angle.

Roll control power variation with airspeed for a VTOGW of 30,000 lbs is shown in Figure 3-38. Unlike pitch control, the thrust modulation roll control power is not reduced due to gas generator EGT at the high thrust levels. Yaw control power variation with airspeed is shown in Figure 3-39.

STOL Control

Roll, pitch, and yaw control power variation with airspeed were also determined for a STOGW of 38,700 lbs. Thrust level and thrust vector angle were determined to trim the aircraft in level flight at zero angle of attack. Pitch control power variation with airspeed is shown in Figure 3-40. Control power due to thrust modulation is plotted only for airspeed greater than 82 knots, which is the minimum

FIGURE 3-37
TRANSITION PITCH CONTROL
VTOGW - 30,000 Lb

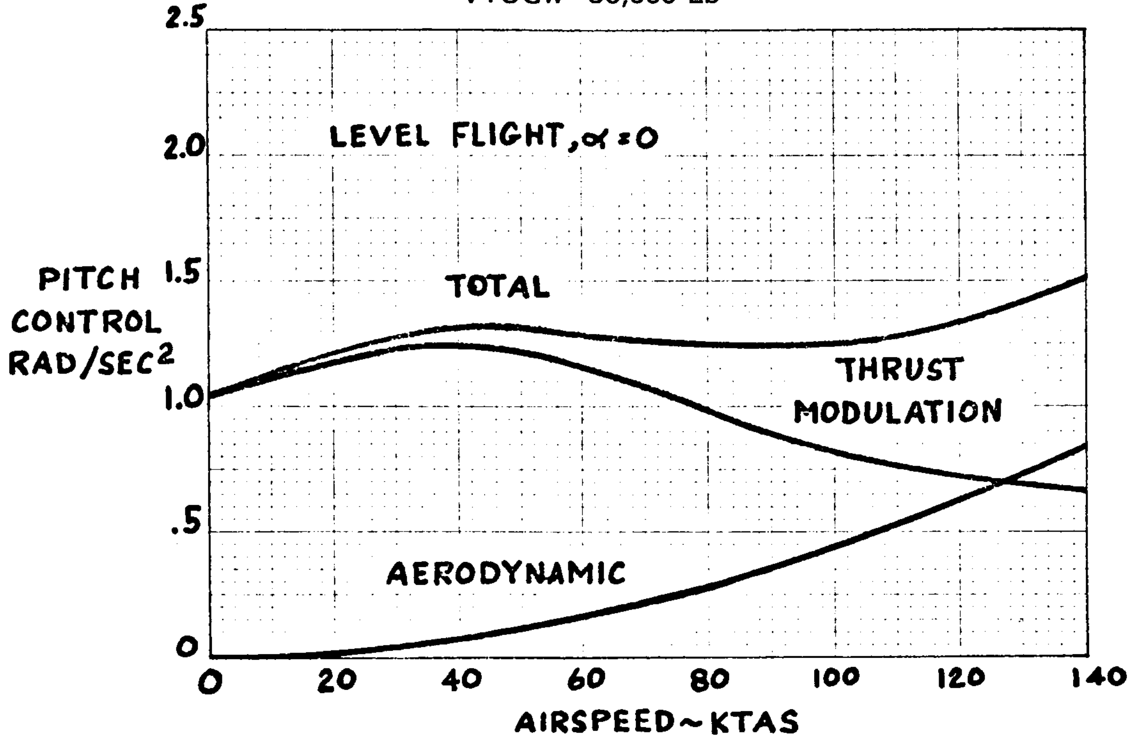


FIGURE 3-38
TRANSITION ROLL CONTROL
VTOGW - 30,000 Lb

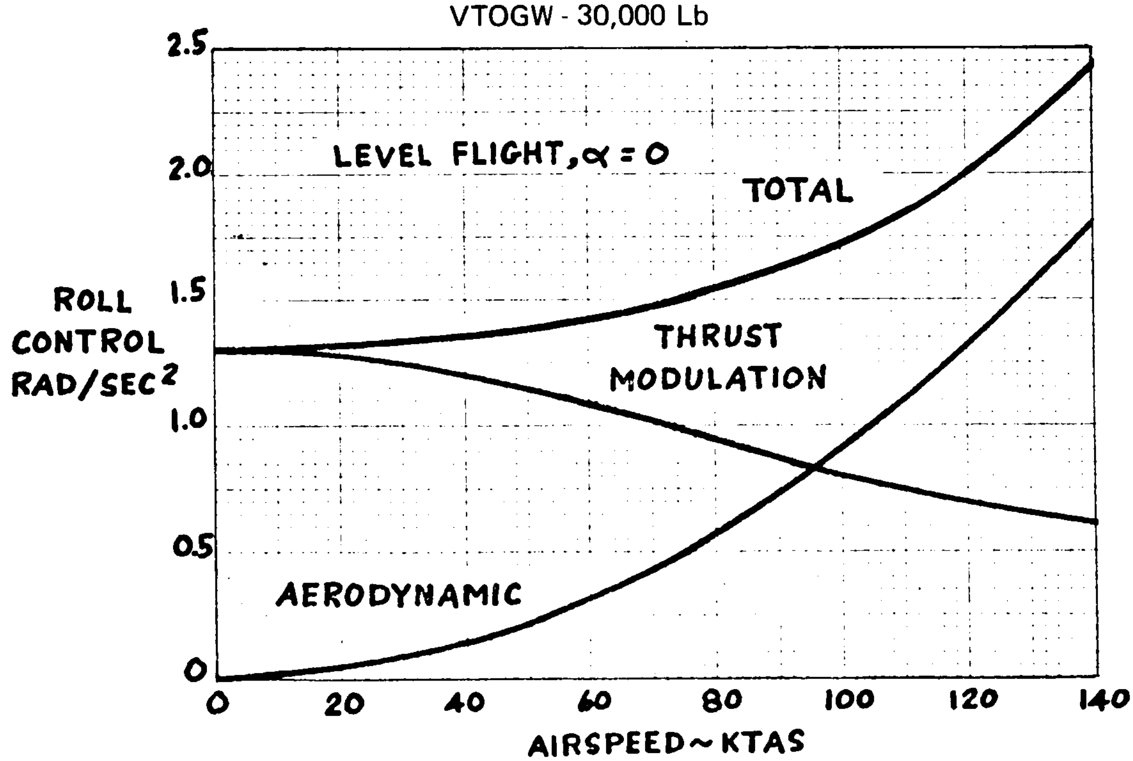


FIGURE 3-39
TRANSITION YAW CONTROL
VTOGW - 30,000 Lb

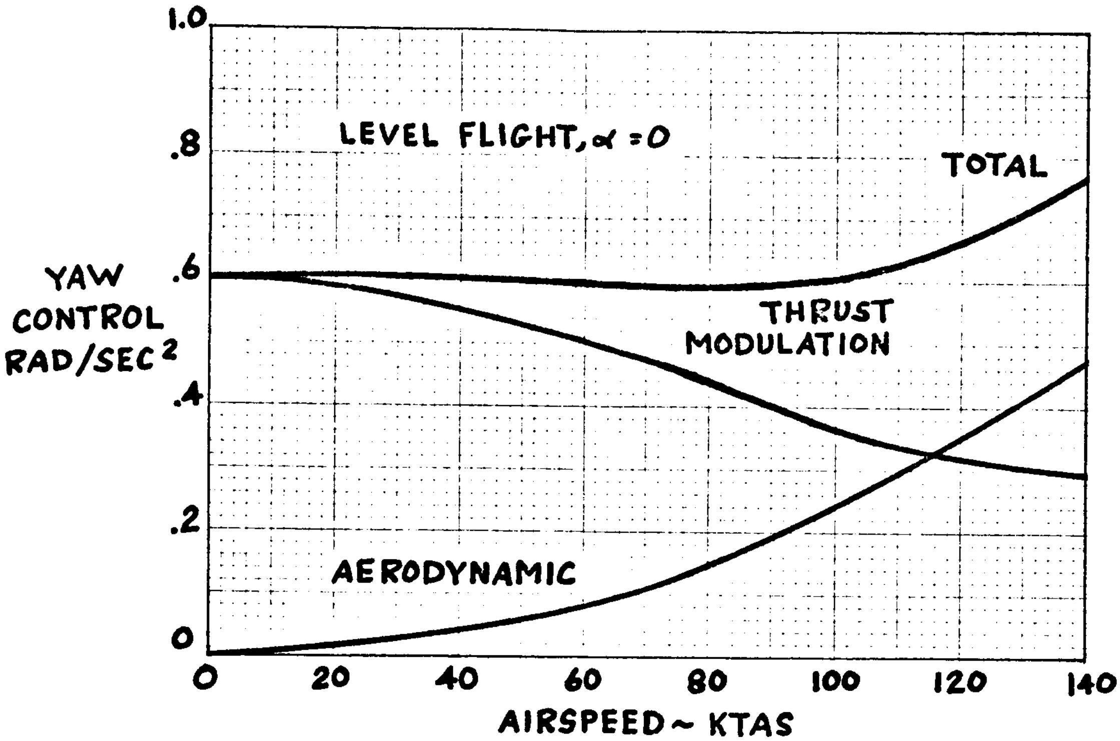
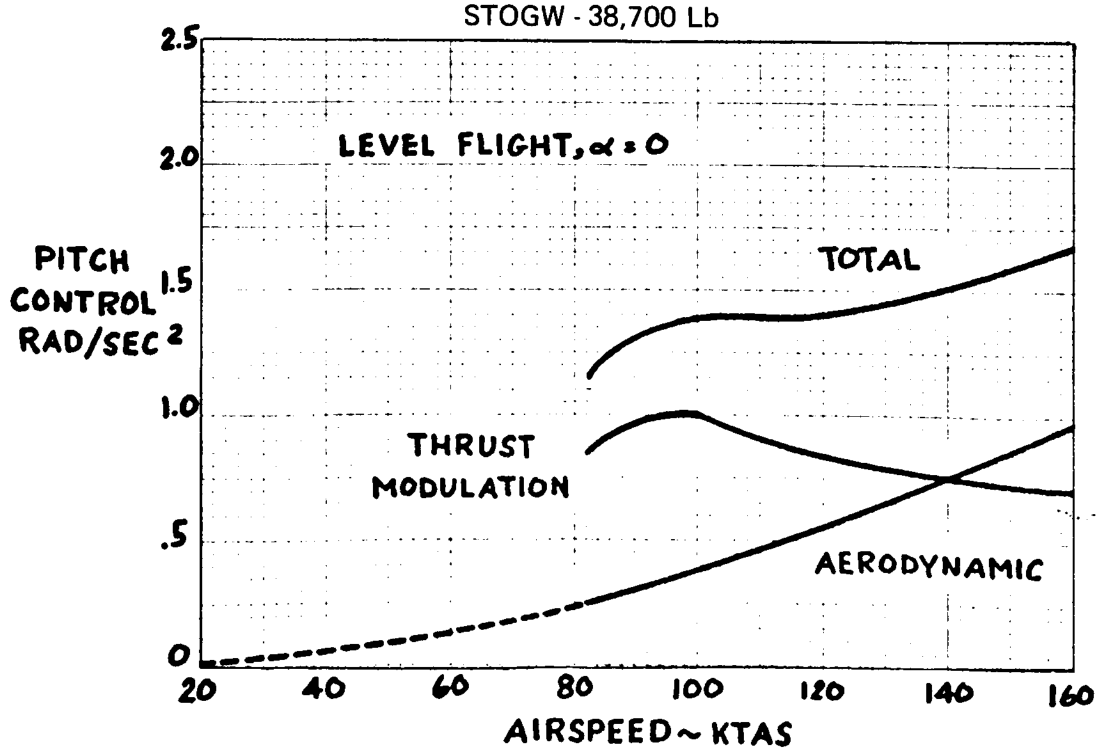


FIGURE 3-40
STOL PITCH CONTROL
STOGW - 38,700 Lb



airspeed for level flight at zero angle of attack. Level flight at 82 knots and zero angle of attack requires intermediate power.

Roll control and yaw control power versus airspeed are presented in Figures 3-41 and 3-42, respectively.

Flying Qualities

Flying quality design efforts during lift/cruise fan V/STOL aircraft development program have been directed primarily toward control design and the resultant trim and maneuver capabilities, and toward the provision of aerodynamic static stability levels generally accepted as prerequisites to desirable handling characteristics.

Standard advanced design analysis methods and techniques have been applied to the aircraft designs to implement their flying qualities. The approach to desirable handling characteristics included:

- Application of the MCAIR V/STOL aircraft technology base to initial design and configuration selection.
- Use of statistical/empirical methods for establishing stabilator area/volume and fin area requirements for aircraft stability.
- Test of wind tunnel models of similarly configured lift/cruise fan aircraft; both high subsonic and low speed evaluations including high angle of attack investigations.
- Integration of the aero-propulsion lift/control system to provide symmetrical thrust and moment characteristics for normal and emergency engine out operations.
- Provision of design flexibility by selection of an active control system with stability augmentation plus a configuration readily adapted to empennage area or wing dihedral adjustment.

The handling characteristics of V/STOL aircraft are highly configuration dependent, especially with regard to the aero-propulsion integrated power effects in both the powered lift and the wingborne flight modes. Therefore, the MCAIR lift cruise fan aircraft development has included wind tunnel test programs with models configured like the missionized and multipurpose aircraft. The most recent test used 4.1 percent scale flow-through models for evaluating the high and low speed, power-off aerodynamic characteristics through high angles of attack. The high T-tail configuration was selected because all experimental data reviewed showed this stabilator location to be optimum with respect to pre-stall stability and control characteristics in wingborne flight, and to power induced effects in and out of ground effect for powered lift flight.

FIGURE 3-41
STOL ROLL CONTROL
STOGW - 38,700 Lb

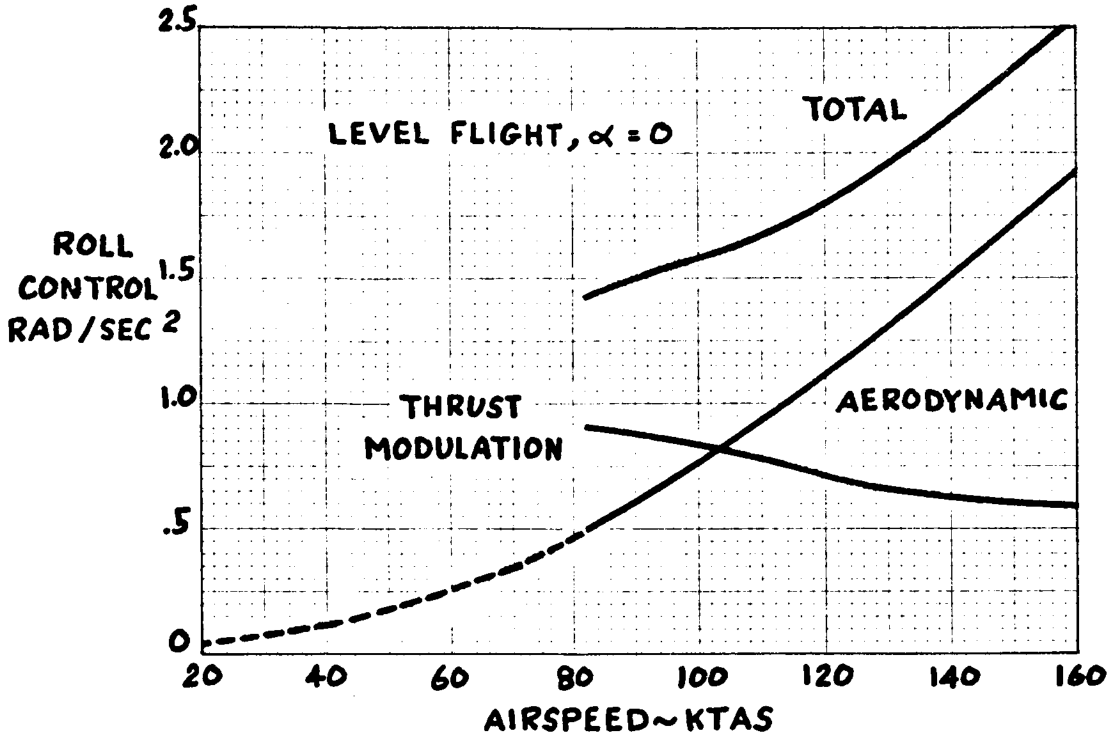
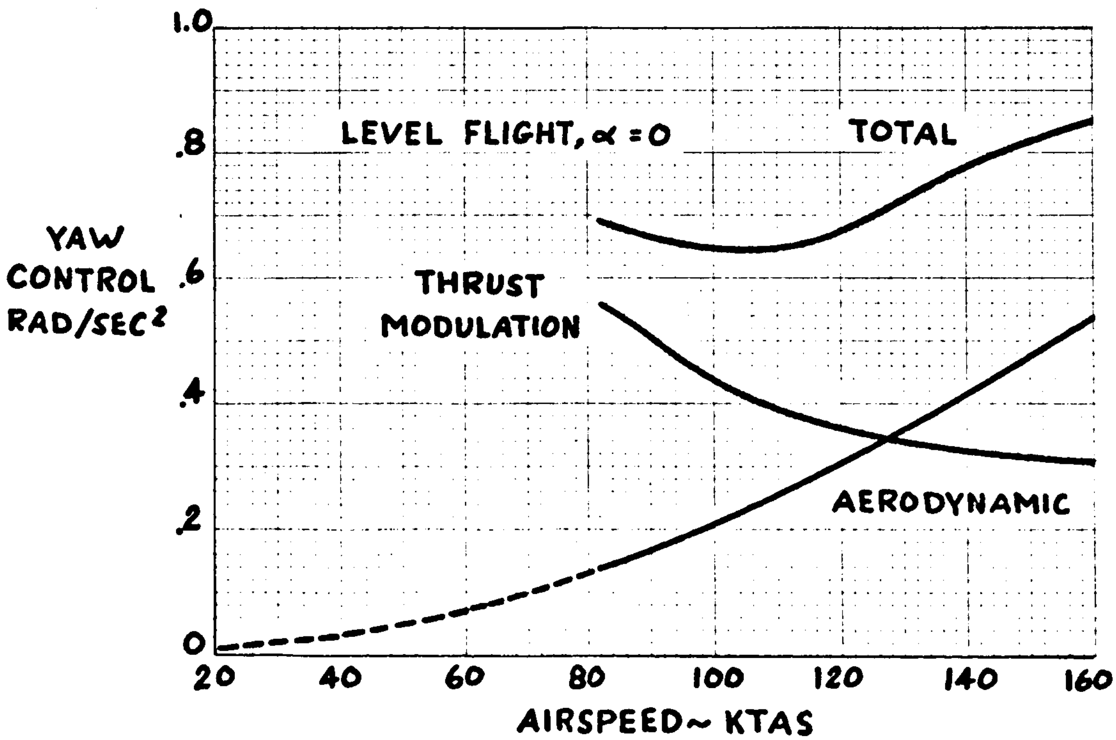


FIGURE 3-42
STOL YAW CONTROL
STOGW - 38,700 Lb



The completed wind tunnel tests substantiated these positive attributes of the proposed empennage configuration. The stability and control summary results from the small scale flow-through model test program establish the following characteristics:

- Positive static longitudinal stability, pre-stall
- Positive static lateral and directional stability at wing stall angle of attack, with the lateral-directional stability ratio conducive to good flying qualities.
- Longitudinal instability post-stall with retention of recovery control power. (Improvement of post-stall characteristics has been demonstrated through the use of auxiliary surfaces on the aft fuselage, stabilator dihedral and an expedient power effects simulation.)
- Reduced powered lift flight downwash flow change with thrust and thrust vector variations at the high tail location which also minimizes empennage excitation from the fan exhaust plumes and stabilator load variation in and out of ground effect.

Flight Controls (Crew Station)

The crew station primary flight controls consist of the control stick, rudder pedals, power lever, and transition lever. Side-by-side seating is provided for pilot and co-pilot with the flight controls duplicated.

The power lever is equipped with a transition lever drive switch and an omnidirectional small angle vectoring control. The drive switch, which is thumb operated, controls a motor which moves the transition lever back and forth at a rate of 12 degrees per second. The omnidirectional small angle vectoring control is also thumb operated and has a vector authority of 6 degrees in any direction from nominal.

Flight Control System

The flight control system is a control-by-wire Active Control System (ACS). Triplex motion sensors, position sensors, and flight control computers are used to achieve a high level of reliability and safety. The FCS computers are hybrid with both the digital and analog paths being used simultaneously. The digital portion has the computational capability required for the various flight control modes, and the flexibility to provide flight control functions specifically tailored for each mission. The analog part of the system provides only those functions which are considered essential to performance of a safe landing in any mode.

Triple electrical and hydraulic power supplies are provided for the flight control system. The design philosophy permits continuation of the mission after a single failure; and safe operation to a vertical landing following the second failure. Appropriate Built-In-Test (B.I.T.) circuits are included to insure satisfactory maintenance performance levels and to provide pilot preflight system check out.

The flight control system has the following modes of operation and associated functions:

- o Conventional Flight Mode
  - Blended pitch rate and normal acceleration command
  - Roll rate command
  - Yaw rate damping and turn coordination
- o Transition Flight Mode
  - Pitch rate command/attitude hold
  - Roll rate command/attitude hold
  - Yaw rate command
- o Hover Mode
  - Pitch attitude command
  - Roll attitude command
  - Yaw rate command
- o Autopilot Modes
  - Control stick steering
  - Pitch attitude hold
  - Roll attitude hold
  - Heading hold
  - Altitude hold
- o Navigation and Flight Path Control Modes
  - Navigation mode
  - Autothrottle
  - Autovector
  - Automatic conventional landing
  - Automatic vertical landing
- o Auxiliary Functions
  - High angle of attack limiter
  - Automatic trim
  - Takeoff trim select (conventional, short, and vertical)
  - Vertical rate damper
  - Thrust splay for rescue mission
- o Built In Test (BIT)
  - Preflight test
  - In-flight monitoring

3.5 AVIONICS

The avionics systems for the missionized and multipurpose aircraft are identical except for the ASW radar. As discussed in the Section 2, a smaller and lighter surface search radar was substituted for the more complex AN/APS-116 ASW radar. The replacement radar can detect large surface vessels in moderate sea states out to 120 nm. The weight of this smaller radar is 132 lb, representing a savings of 318 lb from the 450 lb APS-116 radar for this reduced detection capability. The resultant total avionics system weight for the multipurpose ASW aircraft is 2136.7 lb, while the avionics system weights for all the other missions remain the same.

3.6 DESIGN

The design and mission compromises made to achieve a multipurpose configuration are outlined in Section 3.1, and the common usage high value components and subsystems were identified. The multipurpose aircraft configurations are essentially the same as those generated for the missionized aircraft described in Section 1. All equipment and payloads are identical to those specified for the missionized aircraft, with the exception of the SURV and ASW surface search radar. Detail layout drawings, and spotting factor derivation, are presented in Volume III.

Multipurpose (ASW, CSAR, SA, SURV)

The general arrangement is presented in Figure 3-43 and the major dimensions and design criteria are listed in Figure 3-44. Figure 3-45, illustrates the versatility in the carriage of external stores for the five basic missions and for ferry. A total of five external store stations are provided, three of which are wet. Additional optional stations can be incorporated on the outer panels. Racks for the two MK 46 torpedoes are supported on the same hardpoint structure provided for the centerline stores. The pilot's visibility is plotted in Figure 3-46 and shows an improvement over the Harrier of 15° over the side and 10° in the sector between 0° and 45° azimuth.

Internal fuel for the various missions is as follows:

Tank Location		ASW	SA	SURV	CSAR
Wing	(lb)	8,200	8,200	8,200	8,200
Center Fuselage	(lb)	2,300	2,300	2,300	-
Aft Fuselage	(lb)	1,200	-	1,200	1,200
Additional Aft Fuselage	(lb)	-	-	2,300	2,300

The added requirement in fuel tankage for the SURV and CSAR is made up by the addition of a 2300 lb capacity tank in the aft fuselage. An optional single tank can be considered. The fuel system employs a single point refueling arrangement. Double ended boost pumps assure fuel flow to the engines under all flight conditions and tanks are vented through merging pipes and a vent tank located in the vertical tail. An inflight refueling system is also provided.

Three independent electrical power supplies and three independent hydraulic systems are provided to support the triplex Active Control System (ACS) and utility requirements of the aircraft. The ACS is discussed in Section 3.4. An Airframe Mounted Accessory Drive (AMAD) gearbox, located in the center fuselage, provides drive pads for the following functions:

(a) A Jet Fuel Starter (JFS)

(b) An AC Electrical Generator (including CSD)

(c) A 3000 PSI Hydraulic Pump

FIGURE 3-43
GENERAL ARRANGEMENT MULTIPURPOSE AIRCRAFT
ASW, SA, SURV, CSAR MISSIONS

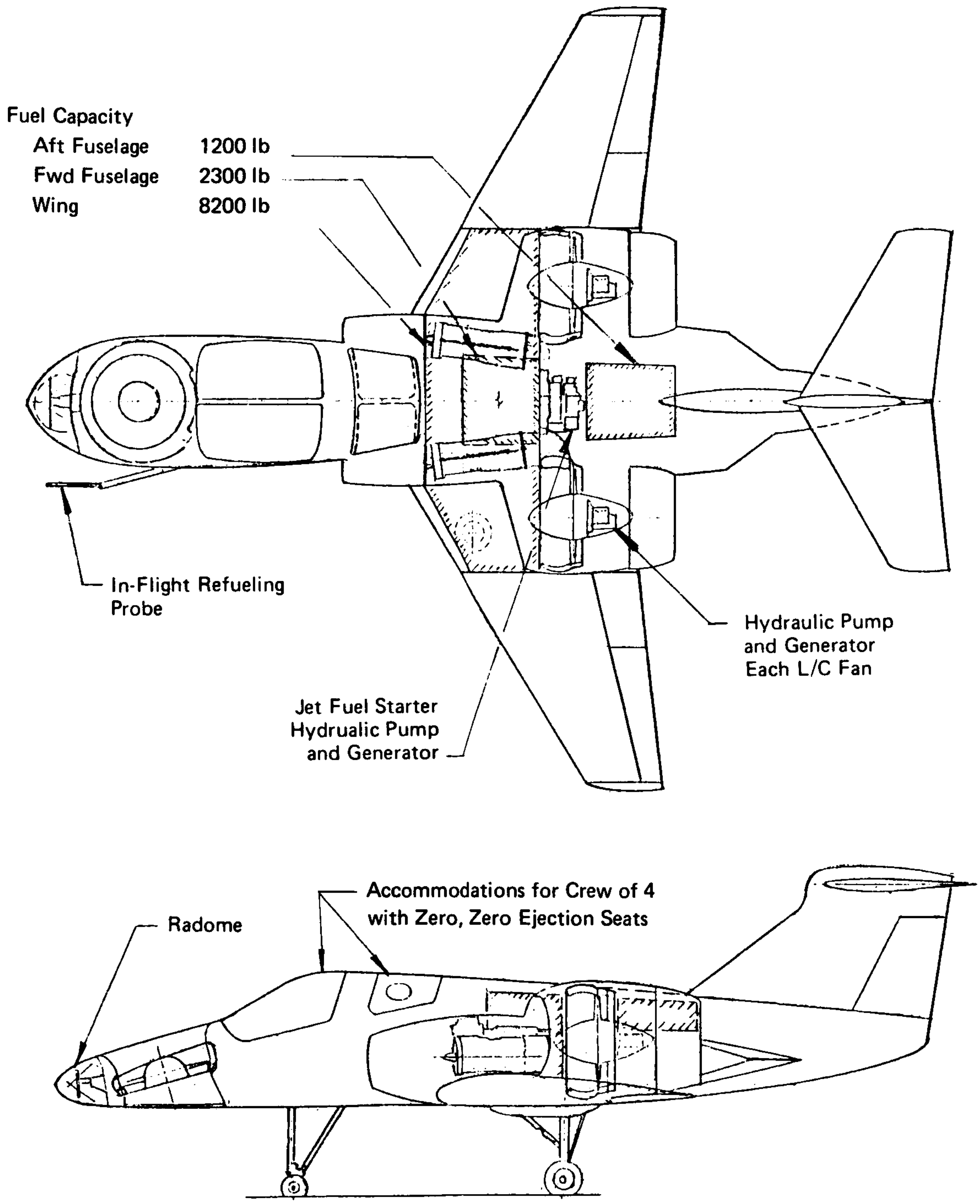
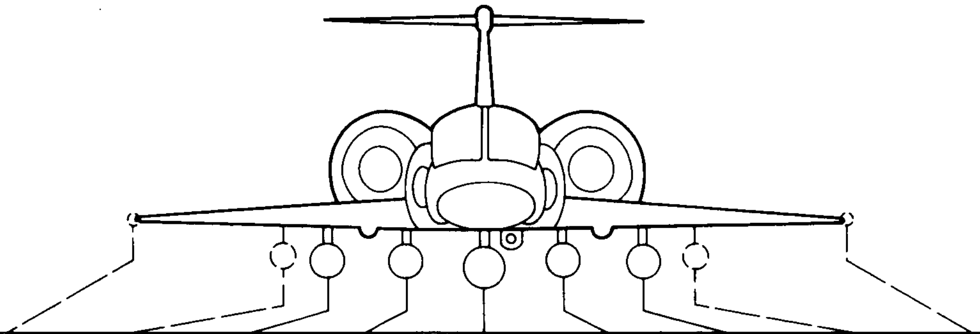


FIGURE 3-44
DIMENSIONS AND DESIGN DATA MULTIPURPOSE AIRCRAFT
for ASW, SA, SURV, CSAR Missions

STOGW	(lb) (N)	38,700 (172,137)
Basic Flight Design GW	(lb) (N)	34,000 (151,232)
VTOGW	(lb) (N)	30,000 (133,440)
Weight Empty	(lb) (N)	19,475 (ASW) (86,625)
Gas Generators	(No. of/W_a)	2/80 lb/sec. 2/(36.29 kg/sec.)
Fan Dia	(in.) (m)	59 (1.50)
Crew Provisions	(No.)	4 (3 in SA)
Max Internal Fuel	(lb) (N)	11,700 (52,041)
Length	(ft) (m)	48.40 (14.75)
Span/Folded	(ft) (m)	41.1/20.3 (12.52)/(6.18)
Height/Adjusted	(ft) (m)	18.0 /17.0 (5.48)/(5.18)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	368 (34.19)	88 (8.18)	68 (6.32)
AR	4.50	3.67	.69
λ	.30	.41	.43
b (ft) (m)	41.10 (12.52)	18.00 (5.48)	6.83 (2.08)
$\Lambda c/4$ (deg)	25.0	25.2	45.5
t/c % Root/Tip	17.4/8	10/8	10
Airfoil	Supercritical (MOdified)	64_AXXX	64_AXXX

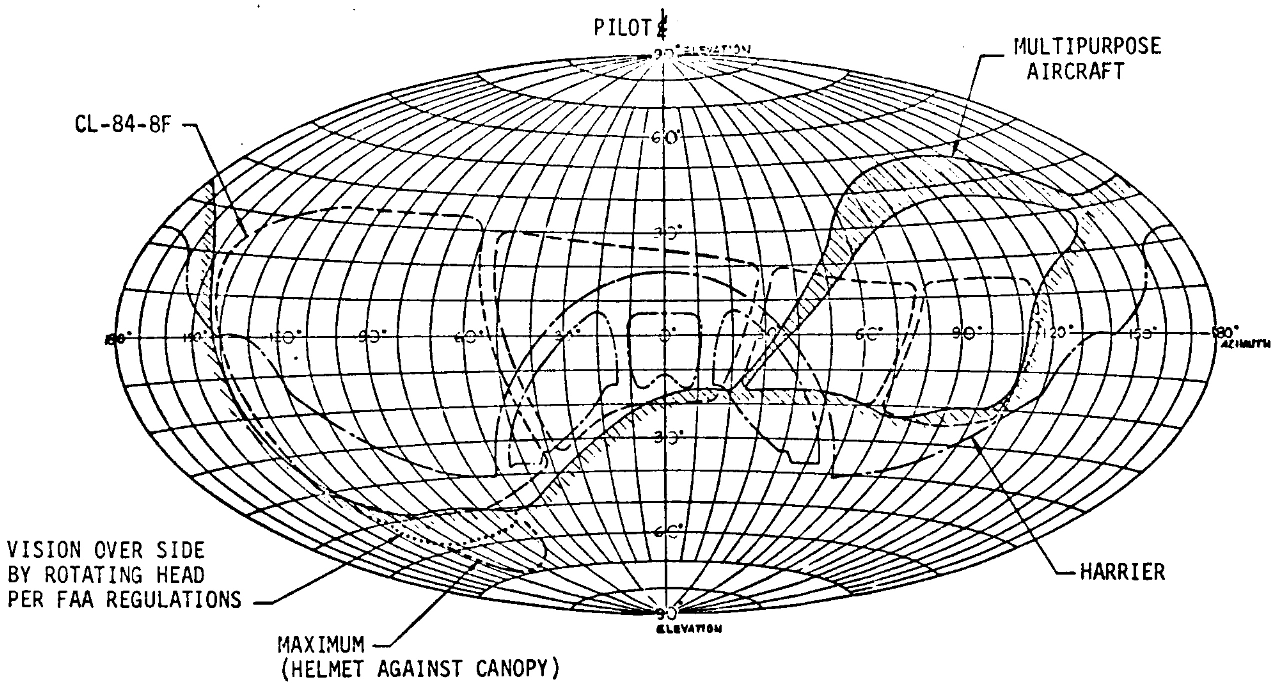
FIGURE 3-45
TYPICAL EXTERNAL STORES



MISSION	TIP	750 LB	3000 LB	1500 LB	3575 LB	1500 LB	3000 LB	750 LB	TIP
ASW	ESM		370 GAL.		MK 46 TORPEDO (2)		370 GAL.		ESM
CSAR			SIDEWINDER		450 GAL. (MINIGUN FWD)		SIDEWINDER		
SURVEILLANCE			370 GAL.		ROTODOME		370 GAL.		
SURFACE ATTACK	ESM		SIDEWINDER	HARPOON	450 GAL.	HARPOON	SIDEWINDER		ESM
		SIDEWINDER	GAU-8	500 LB BOMB (3)	GAU-8	500 LB BOMB (3)	GAU-8	SIDEWINDER	
	SIDEWINDER	500 LB BOMB (1)	500 LB BOMB (6)	500 LB BOMB (3)	GAU-8	500 LB BOMB (3)	500 LB BOMB (6)	500 LB BOMB (1)	SIDEWINDER
			PHOENIX	PHOENIX	450 GAL.	PHOENIX	PHOENIX		
			2000 LB SMART BOMB	500 LB BOMB (2)	450 GAL.	500 LB BOMB (2)	2000 LB SMART BOMB		
			500 LB BOMB (3)	500 LB BOMB (2)	500 LB BOMB (6)	500 LB BOMB (2)	500 LB BOMB (3)		
			CONDOR		CONDOR		CONDOR		
			HARPOON	HARPOON	HARPOON	HARPOON	HARPOON		
FERRY			370 GAL.		450 GAL.		370 GAL.		
SPECIAL			MINES, DEPTH BOMBS AND SPECIAL WEAPONS						

GP75 0013 159

FIGURE 3-46
VISION PLOT



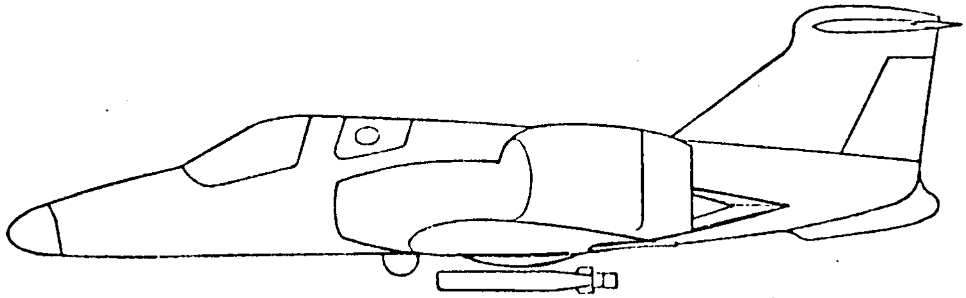
The AMAD is mechanically interconnected to the starter pads of both gas generators and includes clutches for independent gas generator starting and emergency phaseout. Other electrical generators and hydraulic pumps are powered by the lift/cruise fans.

Applications of the multipurpose aircraft to the various Navy missions are shown in Figure 3-47. The three fan configuration has the inherent advantage of separating the fans to provide a clear zone between the fan exhausts in the powered lift mode for rescue operations. The clear zone can be enlarged by splaying the fan exhausts away from the aircraft.

Multipurpose VOD

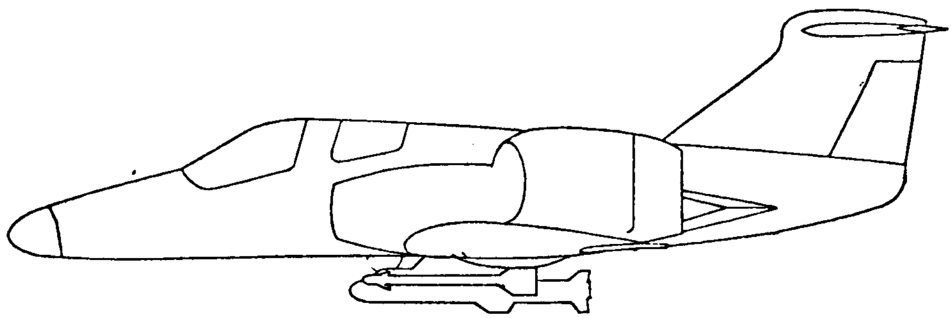
The general arrangement of the VOD is presented in Figure 3-48, and the major dimensions and design criteria are listed in Figure 3-49. The fuselage is essentially the same as that used for the missionized design; however, a 52-inch long section is spliced into the torque box, due to the use of a common wing outboard of the fuselage. The internal fuel distribution is 10,158 lb in the wing and 7842 lb in fuselage tanks. A clear area is provided from the pilot's compartment to the empennage to provide the maximum in utility. This is accomplished by locating both the third gas generator and the AMAD beneath the floor aft of the wing. The cargo bay is 73.5 inches wide at the floor line, which provides ample space for the 54-inch half pallet, its latches and controls. Figure 3-50, illustrates the transport of various types of cargo specified for the VOD mission. The 66-inch wide loading ramp, which incorporates rollers for the 463L loading system, is sufficiently wide to handle such equipment as an M-151 jeep.

FIGURE 3-47
MULTIPURPOSE AIRCRAFT

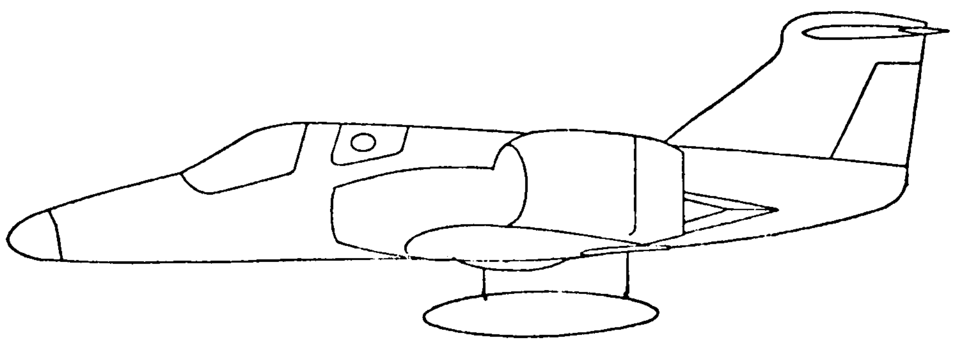


ASW MISSION
Crew 4 Armament
- MK-46 Torpedoes

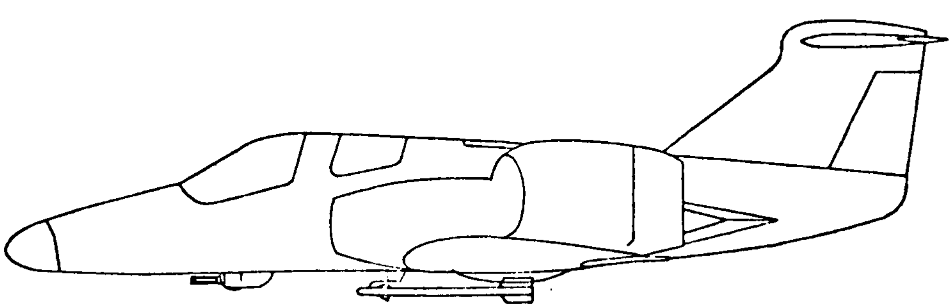
Detection Devices
- 50 Sonobuoys (Class A)
- 8 Markers (18 Launchers)
- Towed MAD



SURFACE ATTACK MISSION
Crew 3 Armament
- Sidewinders 2
- Harpoons 2



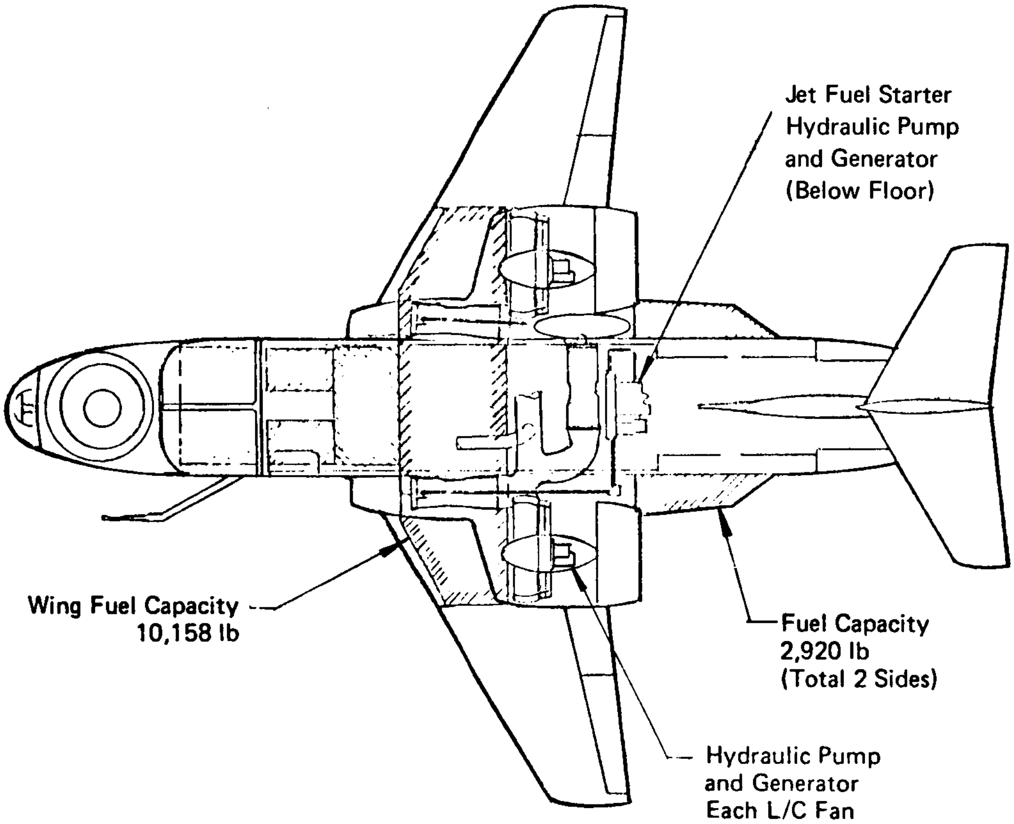
SURVEILLANCE (AEW) MISSION
Crew 4
12 ft Dia Rotodome



COMBAT SEARCH AND RESCUE
Crew - 4
- Pilot and Copilot
- Hoist Operator
- Swimmer

Evacuees - 2
Armament
7.62 mm Minigun - 1
Plus 1,000 rds ammo
Sidewinders - 2

FIGURE 3-48
GENERAL ARRANGEMENT
Multipurpose VOD



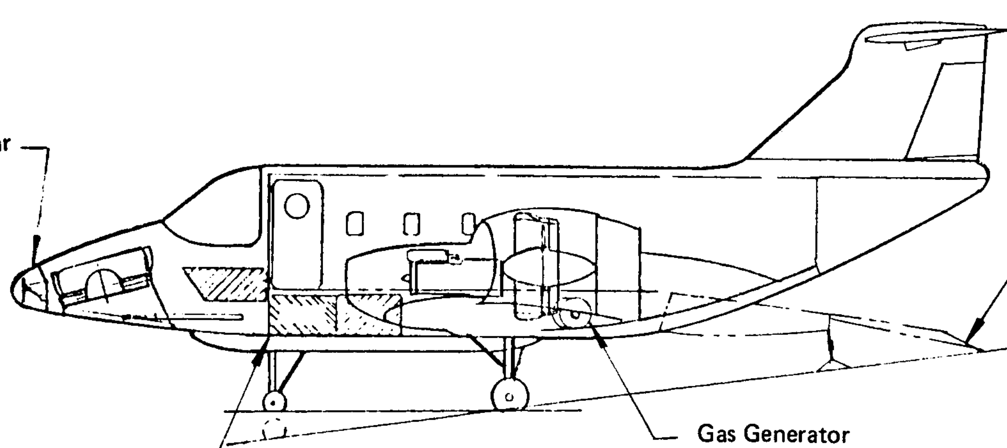
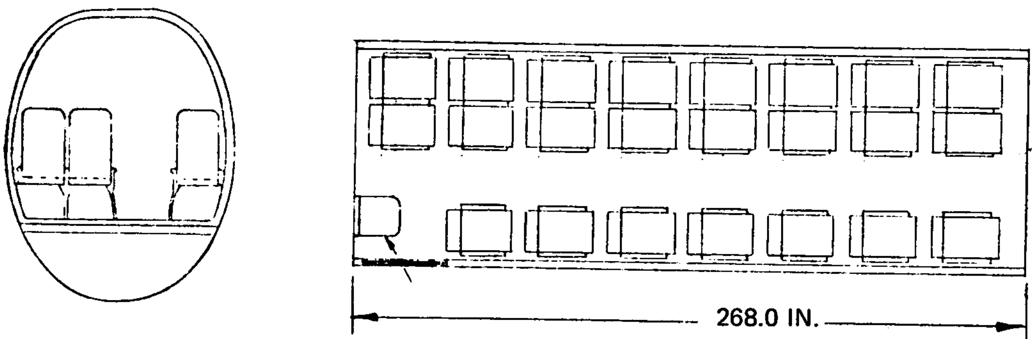


FIGURE 3-49
DIMENSIONS AND DESIGN DATA MULTIPURPOSE VOD AIRCRAFT

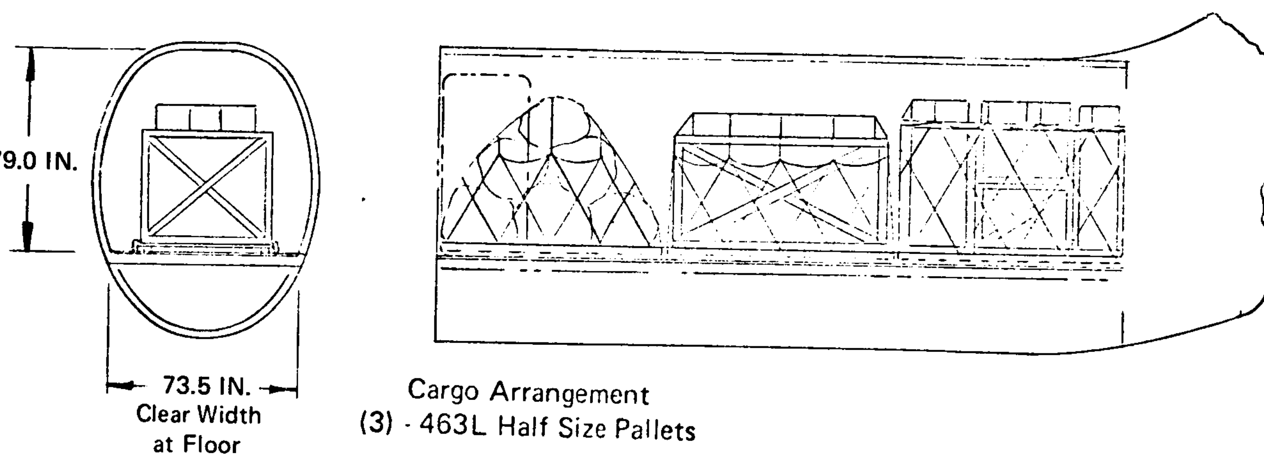
STOGW	(lb) (N)	45,000 (200,160)
Basic Flight Design GW)	(lb) (N)	34,000 (151,232)
VTOGW	(lb) (N)	33,700 (149,897)
Weight Empty	(lb) (N)	19,846 (88,275)
Gas Generators	(No. of/W_a)	3/70 lb/sec 3/(31.75 kg/sec)
Fan Diameter	(in.) (m)	59 (1.50)
Crew Provisions	(No.)	3
Max. Internal Fuel	(lb) (N)	18,000 (80,064)
Length	(ft) (m)	56.70 (17.28)
Span/Folded	(ft) (m)	45.0/25.3 (13.71)/(7.71)
Height/Adjusted	(ft) (m)	22.0/19.0 (6.71)/(5.79)

	Wing	Horizontal Tail	Vertical Tail
S (ft^2) (m^2)	432 (40.13)	88.0 (8.18)	68.0 (6.32)
AR	4.70	3.67	.78
λ	.28	.41	.40
b (ft) (m)	45.00 (13.71)	18.00 (5.49)	7.83 (2.38)
$\Lambda c/4$ (deg)	25.0	25.2	42.0
t/c % Root/Tip	16/8	10/8	10
Airfoil	Supercritical (Modified)	64_AXXX	64_AXXX

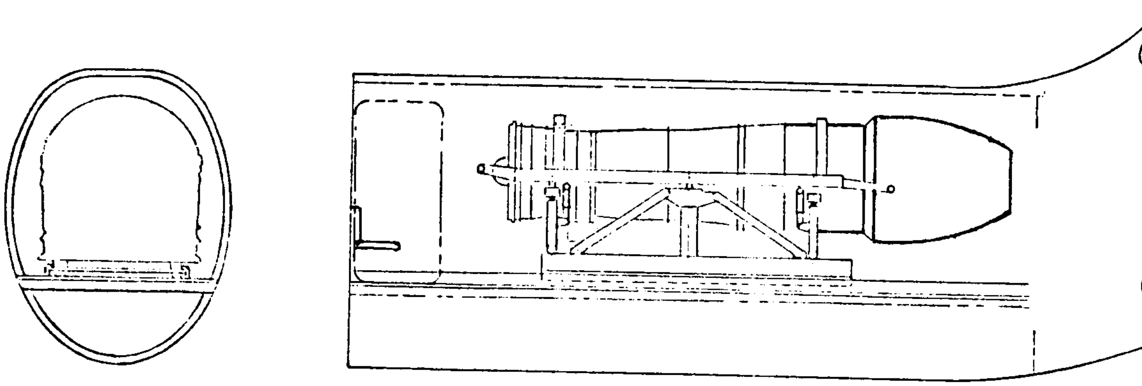
FIGURE 3-50
MULTIPURPOSE VOD
CARGO CAPABILITY



Passenger Arrangement
23 Passengers at 32 In. Pitch



Cargo Arrangement
(3) - 463L Half Size Pallets



Cargo Arrangement
F401-PN-100 Engine with Afterburner on Stand

The VOD size is compatible with carrier operations. With wings folded to the 25.3-foot span, approximately 12 feet of clearance is provided on both sides of a 50 x 34 foot deck edge elevator. Approximately 2.5 feet clearance is provided on each side with wings extended. The common extendable nose gear serves the following purposes aboard the carrier:

(a) Reduces the overall aircraft height to 19.0 feet for hangar deck access and stowage.

(b) Provides flexibility for loading ramp height and angle.

(c) Enhances STO takeoff by increasing wing angle of attack.

The VOD aircraft has fuel, electrical, and hydraulic systems similar to those of the smaller fuselage multipurpose aircraft. The AMAD is interconnected to the third gas generator through a clutch arrangement similar to that of the two gas generator system.

3.7 WEIGHTS AND DESIGN CRITERIA

The multipurpose aircraft described in Section 3.6 were evaluated in accordance with the major design criteria presented in Figure 3-51. The techniques used in the weight evaluation were the same as those used for the missionized aircraft. Group weight statements for the five missions evaluated are presented in Figure 3-53. Advanced materials and fabrication methods were applied to the weights groups and a 13.7% weight saving was realized. An illustration of the graphite epoxy usage and structural weight saved is presented in Figure 3-53 for the ASW.

FIGURE 3-51
DESIGN CRITERIA SUMMARY
Multipurpose Aircraft

	VOD	ASW	SA	SURV	CSAR
Maximum Takeoff Gross Weight (lb) (N)	45,000** (200,160)	38,700 (172,137)	38,700 (172,137)	38,700 (172,137)	38,700 (172,137)
Basic Flight Design Gross WEight*(lb) (N)	34,000 (151,232)	34,000 (151,232)	34,000 (151,232)	34,000 (151,232)	34,000 (151,232)
VTOGW (lb) (N)	33,700 (149,897)	30,000 (133,440)	30,000 (133,440)	30,000 (133,440)	30,000 (133,440)
Ultimate Design Load Factor (g)	4.5	4.5	4.5	4.5	4.5
Maximum Dynamic Pressure (psf) (N/m^2)	535 (25,630)	535 (25,630)	535 (25,630)	535 (25,630)	535 (25,630)
Ult. Differential Cabin Pressure (psi) (N/m^2)	9.4 (64,860)	9.4 (64,860)	9.4 (64,860)	9.4 (64,860)	9.4 (64,860)
Wing Area/Aspect Ratio (ft^2) (m^2)	432/4.7 (40.13)/	368/4.5 (34.19)/	368/4.5 (34.19)/	368/4.5 (34.19)/	368/4.5 (34.19)/
Gas Generator (No. of/W_a (lb/sec) (Kg/sec)	3/70 3/(31.75)	2/80 2/(36.29)	2/80 2/(36.29)	2/80 2/(36.29)	2/80 2/(36.29)
Fan Diameter (in) (m)	59 (1.50)	59 (1.50)	59 (1.50)	59 (1.50)	59 (1.50)
No. of Crew	3	4	3	4	4
Payload	Cargo @ 5000 lb	2 MK-46 50 Sonobuoys	2 Harpoon 2 AIM-9	---	2 Evacuees 2 AIM-9
Maximum Internal Fuel (lb) (N)	18,000 (80,064)	11,700 (52,041)	11,700 (52,041)	11,700 (52,041)	11,700 (52,041)

Notes: * BFDGW = STOGW - 40% Internal Fuel
** At 45,000 lb STOGW, Ultimate Load Factor = 3.9 @ BFDGW

FIGURE 3-52
MULTIPURPOSE AIRCRAFT
Group Weight Statements

Item	VOD	ASW	SA	SURV	CSAR
Wing	1520	1397	1397	1397	1397
Vertical Tail	163	163	163	163	163
Horizontal Tail	180	180	180	180	180
Fuselage	4785	3242	3049	3019	3389
Nose Landing Gear	270	260	260	260	260
Main Landing Gear	633	600	600	600	600
Surface Controls	758	685	685	685	685
Engine Section	221	182	182	182	182
Propulsion					
Gas Generators	2217	1578	1578	1578	1578
Air Induction	222	182	182	182	182
Water Injection System	---	120	120	120	120
Fuel System	696	501	501	501	501
Controls	60	40	40	40	40
Lift Fan	700	700	700	700	700
Lift Fan Louvers	200	200	200	200	200
Lift/Cruise Fans	1400	1400	1400	1400	1400
L/C Fan Deflectors	1300	1300	1300	1300	1300
Ducting	880	594	594	594	594
Valves	551	434	434	434	434
Start/AMAD	350	350	350	350	350
Instruments	234	234	234	234	234
Hydraulics	365	335	335	335	335
Electrical	469	469	469	469	469
Electronics	650	2680	1585	6237	783
Armament	---	313	146	146	884
Furnishings	365	734	598	734	969
Air Conditioning	500	445	445	445	445
Anti-Ice	150	150	150	150	150
Auxiliary Gear	7	7	7	7	7
Weight Empty	19,846	19,475	17,884	22,642	18,531
Crew	540	720	540	720	720
Trapped Fuel	180	105	105	105	105
Oil	135	90	90	90	90
O_2 & Miscellaneous	210	280	210	280	280
Mtg. Hdw. - Missiles or 463L	600	---	468	---	238
- Sonobuoys & Torpedoes	---	300	---	---	---
Gun & Ammo	---	---	---	---	221
H_2O	---	280	280	280	280
Operating Weight Empty	21,511	21,250	19,577	24,117	20,465
Fuel	18,489	14,598	16,411	14,583	17,455
Payload - Missiles or Torpedoes	---	1060	2712	---	380
- Sonobuoys & Markers	---	1792	---	---	---
- Cargo or Evacuees	5000	---	---	---	400
Takeoff Gross Weight (STO)	45,000	38,700	38,700	38,700	38,700

FIGURE 3-53
TYPICAL COMPOSITE WEIGHT SAVINGS
ASW Aircraft

Item	Structural Weight All-Metal Design	Structural Weight Composite Design	Weight Saved	% Saved	Weight Composite Used	Lb Saved per Lb Composite Used
Wing	1771	1397	374	21.1	435	.860
Horizontal Tail	242	180	62	25.6	76	.816
Vertical Tail	218	163	55	25.2	90	.611
Fuselage	3568	3242	326	9.1	513	.637
N.L.G.	292	260	32	11.0	52	.615
M.L.G.	654	600	54	8.3	86	.628
Air Induction	260	182	78	30.0	96	.813
Engine Section	182	182	.0	0	0	0
Totals	7187	6206	981	13.7%	1348	.728

4. CONCLUSIONS

1. The mission requirement of a vertical landing with an engine out was a major design criterion for those aircraft with high non-disposable mission loads. It was the dominant factor in sizing the propulsion system for the Missionized ASW, SURV and VOD aircraft.

2. Only minimal mission compromises were required to establish the Multipurpose aircraft configuration from the five individual Missionized aircraft.

3. The 59" dia fan defined by this study was compatible with both the two growth, three growth and the three existing J97 gas generator systems defined for the Multipurpose aircraft.

4. The Multipurpose lift/cruise fan V/STOL aircraft defined by this study

   - can perform the U.S. Navy missions identified for the 1980's.

   - has excellent short take-off (STO), vertical landing (VL), and rolling vertical landing (RVL) capabilities which obviates the need for catapults and arresting gear.

   - provides engine-out "V" landing capability for all missions except the SURV which has a high fixed avionics payload. The SURV uses an RVL of $<$ 100 ft deck roll with 10 kt WOD.

   - reflects an efficient integration of propulsion/control/airframe subsystems which resulted in a minimum size aircraft.

   - meets or exceeds all performance requirements for SA, CSAR, SURV and VOD missions. The ASW mission can be met with reasonable mission operating alternatives.

   - is capable of high speed (M = 0.83), high altitude (> 40,000 ft) and extended range performance.

5. LIST OF REFERENCES

(1) J97-GE-100 Engine Deck, GE Program P97100, 27 January 1971.

(2) G. A. Phariss/J. L. Porter, "Simulation of Propulsion Engine Cycles (SPEC)," MDC Report A0387, 1 April 1970.

APPENDIX A

GUIDELINES FOR DESIGN DEFINITION STUDY OF A LIFT/CRUISE FAN TECHNOLOGY AIRCRAFT

ATTACHMENT II
Revised Design Guidelines and Criteria
dated October 21, 1974

Enclosure (1) to National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California Letter FPL:237-2(037L:5.0) dated Oct 29 1974

Attachment II

Summary of Missions, Design Guidelines, and Design Technical Information Desired for the Preliminary Aircraft Designs and Multipurpose Aircraft Designed for the Compromise Mission (Part I)

INTRODUCTION

The purpose of Attachment II is to provide the basis for designing the preliminary aircraft of Part I and the multipurpose aircraft designed for the compromise mission as specified in Part I of the Statement of Work. The information is presented in two sections; 1) Mission Summary and Design Requirements, and 2) Technical Information Desired. The Five missions described in Section 1 will replace the missions specified in Part I of the Statement of Work. The information contained in Section 1 will also supply the quantitative performance requirements and flight environment design specifications, including takeoff and landing criteria, payloads, mission equipments, mission profiles, structural design criteria, and ambient conditions for each of the five missions. These design specifications, and performance requirements need not be reviewed by NAVAIR.

Section 2 presents the technical information desired for the preliminary aircraft and for the multipurpose aircraft designed for the compromise mission specified in Part I of the Statement of Work.

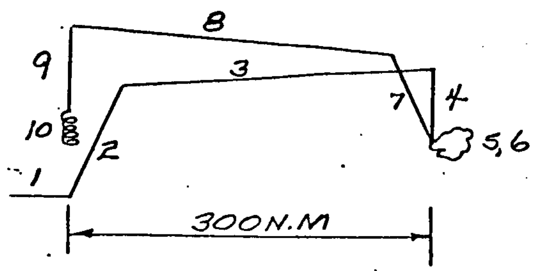
It is possible that the Contractor may not be able to meet these design requirements at a reasonable weight (less than 45,0001bs). If this situation develops, the Contractor should analyze his specific designs and recommend to NASA/Navy any changes which in the Contractor's opinion would result in a more realistic approach.

- 2 -

Mission Summary and Design Requirements

1.0 MISSION SUMMARY

A. Surface Attack (SA) - Sea Control Mission



Loading: (2) Harpoon, (2) AIM-9

Conditions: STO with 400 ft deck run and vertical landing both at 89.8°F. Ten knots WOD for takeoff. All fuel consumption to be calculated at Standard Day Conditions.

Note: External fuel permitted if within STO capability; tanks dropped when empty or prior to combat whichever occurs first.

1. Warm-up, takeoff, accel. to climb speed - 2-1/2 min at intermediate thrust. Installed sea level static conditions.
2. Climb - To BCAV at intermediate thrust.
3. Cruise - To radius to BCAV
4. Descend to 20,000 ft. No fuel used, no time or distance credit.
5. Loiter - 2 hours at 20,000 ft at speed for best endurance.

- 3 -

6. Combat - 5 min at intermediate thrust at 20,000 ft MN = 0.8.

7. Climb - From 20,000 ft to BCAV at intermediate thrust

8. Cruise - At BCAV to point of takeoff

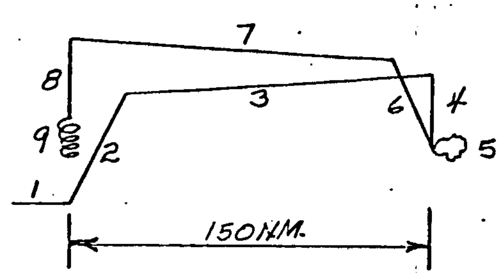
9. Descend to Sea Level - No fuel used, no time or distance credit.

10. Landing Allowance and Reserve - fuel for:

    (a) 10 min loiter at best endurance speed at sea level

    (b) 5% total initial fuel

B. Antisubmarine (ASW)



Loading: (2) MK - 46 torpedoes, (50) mixed sonobuoys - (sonobuoys wt 1760 lb)

Conditions: STO with 400 ft deck run and vertical landing, both at 89.8°F. Ten knots WOD for takeoff. All fuel consumption to be calculated at Standard Day Conditions.

1. Warm-up, takeoff, accel. to climb speed - 2-1/2 at intermediate thrust. Installed sea level static conditions.

2. Climb - To BCAV at intermediate thrust

3. Cruise - To radius at BCAV

- 4 -

4. Descend - To 10,000 ft no fuel used, no time or distance credit.

5. Loiter - At 10,000 ft and speed for best endurance - 4 hrs desired.

6. Climb - At intermediate thrust to BCAV

7. Cruise - To starting point at BCAV

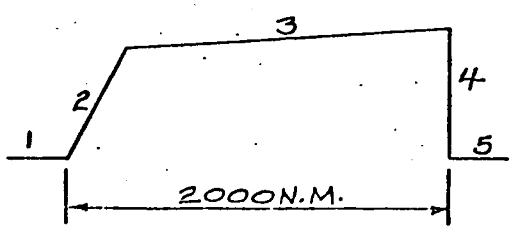
8. Descend - To sea level. No fuel used no time or distance credit

9. Landing Allowance and Reserve - fuel for:

   (a) 10 min at best endurance speed at sea level

   (b) 5% total initial fuel

C. Vertical Onboard Delivery (VOD)



Loading:	5000 lb disposable payload, may include pallets, but not life rafts, cargo loading equipment, etc.
Conditions:	STO with 450 ft deck run and vertical landing, both at 89.8°F. Twenty knots WOD for takeoff. All fuel consuption to be calculated at Standard Day Conditions.

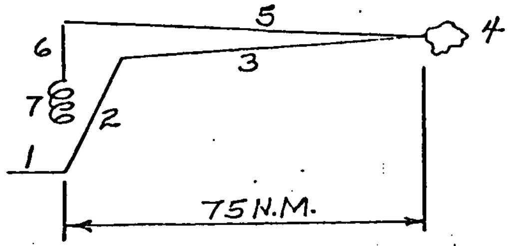
1. Warm-up, takeoff, accel. to climb speed - 2-1/2 min at intermediate thrust. Installed sea level static conditions.
2. Climb - To BCAV at intermediate thrust.
3. Cruise - To radius at BCAV.
4. Descend - To sea level. No fuel used no time or distance credit.
5. Landing Allowance and Reserve - Fuel for:
   (a) 20 min loiter at best endurance speed at sea level.
   (b) 5% total initial fuel

Note: VOD designs should be sized to carry at least the following:

(a) Passengers: 17 - 23 plus 3 crew
(b) 350 in rotor blade
(c) F401 engine on stand (no afterburner)
(d) 463L Half pallet
(e) TF34 engines on stand

If internal carriage of the rotor blade creates an adverse impact upon the aircraft design external carriage may be considered. External carriage of blades up to 420 inches long should be examined.

D. Surveillance



Conditions: STO with 400 ft deck run and vertical landing both at 89.8°F. Ten knots WOD for takeoff. All fuel consumption to be calculated at Standard Day Conditions.

Loading Mission Avionics

1. Warm-up, takeoff, and accel. to climb speed - 2-1/2 min. at intermediate thrust. Installed sea level static conditions.
2. Climb - To BCAV at intermediate thrust
3. Cruise - To radius at BCAV
4. Loiter - On station 4 hours at best endurance speed at 25,000 ft or higher
5. Cruise - To point of takeoff at BCAV
6. Descend - To sea level. No fuel used no time or distance credit.
7. Landing allowance and reserve - Fuel for:
   (a) 10 min loiter at best endurance speed at sea level
   (b) 5% total initial fuel

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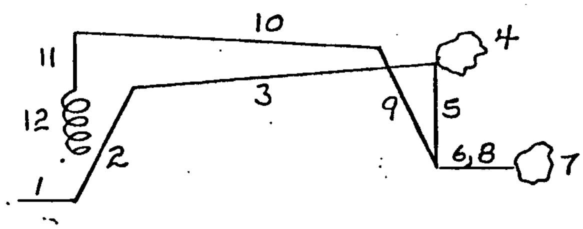
E. Combat (Strike) Search and Rescue (CSAR)



Loading: (2) AIM-9, MINI GUN and 1000 Rounds AMMO (all retained) and 600# Armor

Conditions: STO with 400 ft deck run, mid-point hover, and vertical landing at 89.8°F. All fuel consuption to be calculated at Standard Day conditions.

Note: External fuel permitted if within STO capability, tanks dropped when empty or prior to hover whichever occurs first.

1. Warm-up, takeoff, accel to climb speed - 2-1/2 min at intermediate thrust. Installed sea level static conditions.
2. Climb - To BCAV at intermediate thrust
3. Cruise - To 350 nm at BCAV less distance covered in climb
4. Loiter - 20 min at optimum altitude and airspeed
5. Descent - To sea level, no fuel used, no time or distance credit.

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6. Dash - 50 nm at sea level, Mach 0.8 to pickup area
7. Personnel Pickup - Fuel allowance for 10 min hover at sea level (OGE) pickup 2 personnel (400 lb)
8. Dash - At Mach No. 0.8, 50 nm at sea level
9. Climb - To BCAV at intermediate thrust
10. Cruise - At BCAV to point of takeoff, 350 nm less distance covered in climb.
11. Descend - To sea level. No fuel used, no time or distance credit.
12. Landing Allowance and Reserve - Fuel for:
    (a) 10 min loiter at best endurance speed at sea level
    (b) 5% total initial fuel

MISSION NOTES

1. If a short term engine rating is developed which provides greater than intermediate thrust for takeoff the takeoff fuel allowance shall be calculated as the sum of:
    a. 2 minutes at intermediate thrust
    b. 1/2 minute at takeoff thrust
2. All mission calculations shall include 5% fuel flow tolerance.
3. BCAV: Best cruise altitude velocity
4. Crew complement: SA-3, ASW-4, VOD-3, Surveillance-4, C(STRIKE) SAR- 4

2.0 V/STOL PERFORMANCE

A. VERTICAL TAKEOFF (VTO)

1. 89.8° at sea level
2. WOD - variable direction/velocity, no lift contribution
3. Trimmed flight condition
4. Ratio of net vertical force to takeoff weight = 1.05 in and out of ground effect
5. Propulsion induced effects and losses due to trim requirements should be accounted for

B. SHORT TAKEOFF (STO)

1. 89.8°F at sea level
2. Available deck run distance is for main gear travel
3. Horizontal acceleration at least .065 g after liftoff
4. For aircraft rotation/reconfiguration after liftoff contractor should specify criteria used in defining and constraining the takeoff

C. TAKEOFF AND LANDING TRANSITION

Transition to wing borne flight will be accomplished at speeds not less than 120% of power-on stall speed for fully wing-borne flight. In addition, an acceleration of .065 A/G will be possible throughout a (level flight) transition.

3.0 STRUCTURES AND DESIGN WEIGHTS

A. STRUCTURAL CHARACTERISTICS

1. Strength of MIL-A-8860 series is desired except +5.0 g limit load factor for SAR aircraft at Flight Design Gross Weight.

B. COMBAT WEIGHT AND FLIGHT DESIGN WEIGHT

1. Basic mission takeoff weight less 40% full internal fuel.

C. MAXIMUM DESIGN GROSS WEIGHT

1. 1.1 times the maximum weight of the aircraft with the heaviest combination of internal and external loadings which can be attached.

D. LANDING DESIGN GROSS WEIGHT

The maximum vertical takeoff weight; contractor should specify.

E. SINKING SPEED

15 fps at the Landing Design Gross Weight

4.0 ARMAMENT/STORES

1. Contractor should specify store station locations, capacities, etc.
2. One turret mounted 7.62 mm gun with 1000 rounds AMMO (CSAR mission only).

3. At least two wet stations will be required.
4. Contractor should provide the type and quantity of all stores which his aircraft will be designed to carry (consistent with IOC 1985.

5.0 AVIONICS AND MISSION EQUIPMENT

The Contractor should provide equipment necessary to assure effective prosecution of the various missions. Weights and volumes generated by NAVAIR for the "Medium VTOL Systems Analysis Study" may be used as a starting point. Sections of that study relating to avionics and weapon loadings will be available upon request to Naval Air Systems Command, Code AIR-503.

6.0 PROPULSION

Propulsion systems for this 1985 IOC aircraft shall be restricted to present engines now in service or development. If these engines prove inadequate in performance specified derivatives of these engines can be used. Fan designs shall have a firm technology base consistent with IOC 1985.

7.0 FLYING QUALITIES

MIL-F-8785B and MIL-F-83300 may be used as guides unless otherwise modified by NASA/Navy instructions.

8.0 MATERIALS

The use of advanced materials should be consistent with the desired IOC. Total structural weight reductions greater than 15% and any new or unusual uses of advanced material, particularly in the primary structure, should be accompanied by adequate cost justification.

9.0 GENERAL CONSIDERATIONS

A. The Contractor should adequately consider and provide information on unique operational procedures required of his design. It is expected that the aircraft will operate from hard surfaced runways ship decks such as LPH, LHA, LPD, SCS.

B. Improved visibility, current Harrier visibility is inadequate.

C. Inflight refueling capability.

D. Zero-zero escape system, not requirement for VOD mission

E. Automatic landing approach systems.

F. Self contained starting system.

G. Emergency jettison of all stores with landing gear down.

H. No engine-out requirement except (1) capability for a 500 ft/min rate of climb at takeoff weight at best climb speed at sea level at 90°F and, (2) emergency vertical landing at maximum sink speed of 15 FPS with 1000 lb fuel and no stores at 90°F at sea level.

I. Continued flight with engine failure during takeoff is not required. The pilot, however, shall be able to maintain a horizontal attitude until impact during an engine failure during takeoff.

J. Aircraft shall be compatible with a 34 x 50' elevator. Tail height shall not exceed 19 ft.

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DESIRED TECHNICAL INFORMATION

1.0 GENERAL - Submit the necessary technical information to permit an evaluation of each optimized conceptual design approach of Part I, construction and capabilities, include background concerning the evolution of the design and any special features. Particular attention is called to the following information which is considered essential for analysis of the contractors response. Additional data on tradeoff studies, weights, aerodynamics, structures, performance, flying qualities, etc. may be submitted if desired. The following information is required in full for the compromise mission aircraft. Items marked by an asterisk (*) are the only information required for the preliminary conceptual aircraft optimized for each mission.

2.0 SUMMARY OF CHARACTERISTICS

* A. Takeoff weights, radii, loiter time, etc. (as applicable) for each mission specified.

B. Breakdown of specified missions; weight altitude, speed, fuel used, distance, and time for each segment.

* C. Max. Mach No. vs altitude and combat ceiling vs Mach No. at combat weight and loading.

D. Maximum sustained, maximum usable and buffet onset load factor at Mach 0.30 at sea level and Mach 0.65 and V_{max} at 10,000 ft at combat weight and loading, if available.

3.0 GENERAL DIMENSIONAL AND DESIGN INFORMATION

* A. 3-view general arrangement drawing
* B. Drawing showing propulsion system arrangement
  C. Store locations, stores carried, design capabilities, etc.
* D. Lifting surface planform dimensions/areas (theoretical and exposed) and wetted areas of all aircraft components
* E. Airfoil sections including leading edge radius and design lift coefficient.
* F. Dimensions, extensions, deflections of lift and drag increasing devices if employed.
* G. Landing Gear Geometry
  H. Spotting factor relative to A-7.

4.0 WEIGHT AND BALANCE

* A. Group weight statement including "Dimensional and Structural Data" page basis of estimates provided, including increments for special features or advanced materials usage.
  B. Estimated c.g. locations vs gross weight for each specified mission (include takeoff and landing configuration).
  C. Estimated inertia in each axis for VTO and VL configurations.

5.0 STRUCTURES

* A. Max. permissible speed and design load factors.
* B. Derivation of flight design, landing design, and max. design weights.
* C. Summation of structural design criteria including materials usage and v-n diagrams.

6.0 EQUIPMENT

A. Description of Flight Control System including operation and performance of surface or reaction controls, thrust vectoring or modulation.

B. Describe avionics and armament systems and installations.

7.0 PROPULSION

A. DATA - Engine and fan system performance used to calculate mission capability including the following:

* 1. Net thrust and fuel flow.
2. Gross thrust and ram drag.
3. Propulsion/aerodynamic interaction.
* 4. Factors used to determine installed performance including estimated losses and derivations thereof including any hot gas reingestion and propulsion induced effects.
5. Effect of ambient temperature on engine thrust and total lift thrust.
* 6. Location/orientation of all propulsion system components contributing to net vertical lift and information sufficient to verify that a thrust balance can be established.

B. THRUST/DRAG ACCOUNTING - Contractor's "bookkeeping" system should be thoroughly described.

8.0 AERODYNAMICS

* A. Plots VS Mach No. of: $C_{D_{min}}$, C_L for $C_{D_{min}}$, trimmed "e" for range of C_L's, buffet onset and max usable C_L, zero lift angle of attack, ΔC_D for external stores, C_{L_α}.

* B. Trimmed C_L, C_D for cruise, VTO, and STO configurations, with and without ground effects where applicable.

See note below.

9.0 V/STOL CHARACTERISTICS (if available)

Time histories for VTO and STO with complete transition (speed, alpha, thrust angles, power settings, etc.)

NOTE: * Plotted data for basic configuration is required, but either plotted or incremental data is acceptable for each separate aircraft design.